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Survey of Insulation Used in Nuclear Power Plants and the Potential for Debris Generation

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Prepared by R. Reyer, E. Gahan, J. W. Riddington

Burns and Roe, Inc.

Prepared for
U.S. Nuclear Regulatory
Commission

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ABSTRACT

In support of Unresolved Safety Issue A-43, "Containment Emergency Sump Performance," 11 nuclear power plants representative of different U.S. reactor manufacturers and architect-engineers were surveyed to identify and document the types and amounts of insulation used, location within containment, components insulated, material characteristics, and methods of installation and attachment. A preliminary assessment was made of the potential effects of insulation debris generated as the result of a loss-of-coolant accident (pipe break).

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CONTENTS

Page

ABSTRACT iii
LIST OF FIGURES vii
LIST OF TABLES x
ACKNOWLEDGMENTS. xi
LIST OF ABBREVIATIONS. xii

1. INTRODUCTION 1
2. REACTOR PLANTS INVESTIGATED. 1
3. TYPES OF INSULATION. 2
4. SUMMARY. 6
5. REFERENCES 7

APPENDIXES

Appendix A - Description of Insulation Found in Plants Surveyed A-1

Appendix B - Emergency Sump Dimensions for Plants Surveyed. B-1

Appendix C - Crystal River Unit 3: Preliminary Assessment of Insulation Debris Generated During a Pipe Break Event C-1

Appendix D - Oconee Unit 3: Preliminary Assessment of Insulation Debris Generated During a Pipe Break Event. D-1

Appendix E - Midland Unit 2: Preliminary Assessment of Insulation Debris Generated During a Pipe Break Event. E-1

Appendix F - Maine Yankee: Preliminary Assessment of Insulation Debris Generated During a Pipe Break Event. F-1

Appendix G - Arkansas Unit 2: Preliminary Assessment of Insulation Debris Generated During a Pipe Break Event. G-1

Appendix H - Waterford Unit 3: Preliminary Assessment of Insulation Debris Generated During a Pipe Break Event. H-1

Appendix I - Salem Unit 1: Preliminary Assessment of Insulation Debris Generated During a Pipe Break Event. I-1

Appendix J - Sequoyah Unit 2: Preliminary Assessment of Insulation Debris Generated During a Pipe Break Event. J-1

CONTENTS

Page

Appendix K - McGuire Units 1 and 2: Preliminary Assessment of Insulation Debris Generated During a Pipe Break Event K-1

Appendix L - Cooper Station: Preliminary Assessment of Insulation Debris Generated During a Pipe Break Event. L-1

Appendix M - Washington Public Power Supply System Nuclear Project 2: Preliminary Assessment of Insulation Debris Generated During a Pipe Break Event. M-1

LIST OF FIGURES

Figure Number Page

A-1 Specially Designed Mirror Valve and Elbow Insulation for 24" Residual Heat Removal at Vermont Yankee Nuclear Station A-5

A-2 Mirror Insulation A-6

A-3 Typical Buckled Panel Arrangement A-7

A-4 Typical Banded Panel Arrangement. A-8

A-5 (a) Calcium Silicate Molded Block Insulation;
(b) Fiberglass Molded Block Insulation;
(c) Installed Calcium Silicate Insulation . . A-9

A-6 Calcium Silicate or Unibestos Molded Block Jacketed Insulation A-10

B-1 Emergency Recirculation Sumps and Piping for Surveyed Plants B-2

C-1 Reactor Containment Arrangement, Crystal River Unit 3. . . . . C-8

C-2 Reactor Containment, Crystal River Unit 3 . . C-9

C-3 Primary Containment, Crystal River Unit 3 . . C-10

C-9 Reactor Building Pump Screen Assembly, Crystal River Unit 3. . . . . C-11

D-1 Primary Containment, Oconee Unit 3. . . . . . D-9

D-2 Reactor Building Plan, Oconee Unit 3. . . . . D-10

D-3 Emergency Sump, Oconee Unit 3 . . . . D-11

E-1 Reactor Containment Arrangement, Midland Unit 2. . . . . E-7

E-2 Primary Containment, Midland Unit 2 . . . . . E-8

E-3 Detailed Drawing of Sump, Midland Unit 2. . . E-9

F-1 Reactor Containment Arrangement, Maine Yankee F-5

F-2 Reactor Containment, Maine Yankee F-6

F-3 Emergency Sump Screen, Maine Yankee F-7

LIST OF FIGURES (Cont'd)

Figure Number		Page
G-1	Reactor Containment Arrangement Arkansas Unit 2	G-6
G-2	Emergency Intake Sump, Arkansas Unit 2.	G-7
G-3	Pathways of Insulation Debris to Emergency Intake Sump, Arkansas Unit 2.	G-8
H-1	Reactor Containment Arrangement, Waterford Unit 3.	H-6
H-2	Reactor Containment Arrangement With Sump Location, Waterford Unit 3.	H-7
H-3	Emergency Intake Sump, Waterford Unit 3	H-8
H-4	Pathways of Insulation Debris to Emergency Intake Sump, Waterford Unit 3	H-9
I-1	Reactor Containment Arrangement, Salem Unit 1.	I-6
I-2	Reactor Containment Arrangement Plan View, Salem Unit 1.	I-7
I-3	Emergency Sump Detail, Salem Unit 1	I-8
J-1	Primary Containment, Sequoyah Unit 2.	J-7
J-2	Primary Containment Plan View, Sequoyah Unit 2	J-8
J-3	Emergency Sump, Sequoyah Unit 2	J-9
J-4	Plan View of Emergency Sump, Sequoyah Unit 2	J-10
K-1	Reactor Containment Plan View, McGuire Units 1 and 2.	K-9
K-2	Reactor Containment, McGuire Units 1 and 2	K-10
K-3	The Revised Design of Containment Sump, McGuire Unit 1.	K-11
K-4	Revised Design of Containment Recirculation Sump, McGuire Unit 1.	K-12
K-5	Molded Portion of Containment Revised Design Sump, McGuire Unit 1	K-13

LIST OF FIGURES (Cont'd)

Figure Number		Page
L-1	Reflective Insulation	L-11
L-2	(a) Typical Panel Cross Section, (b) Typical End Lap	L-12
L-3	Removable Panel	L-13
L-4	Primary Containment Vessel, Cooper Station	L-14
L-5	Suppression Chamber, Cooper Station	L-15
L-6	Dry Well Shell Stretchout, Cooper Station	L-16
L-7	Dry Well, Cooper Station	L-17
L-8	Reactor Containment, Cooper Station	L-18
L-9	Suppression Chamber Vents, Cooper Station	L-19
L-10	Suppression Chamber Penetrations, Cooper Station	L-20
M-1	Primary Containment Vessel, WPPSS Unit 2	M-9
M-2	Composite at El. 501'0", Primary Containment, WPPSS Unit 2	M-10
M-3	Jet Deflector With 24" Diameter Downcomer	M-11
M-4	Reflective Insulation for a 4" Pipe	M-12
M-5	Suction for ECCS Pumps in Wetwell, WPPSS Unit 2	M-13

LIST OF TABLES

Table		Page
2-1	Reactor Plants Selected for Insulation Survey	3
3-1	Types and Percentages of Insulation Used Within the Primary Coolant System Shield Wall in Plants Surveyed	5
4-1	Summary Table	7

ACKNOWLEDGMENTS

This report was prepared as part of the work under USNRC "Unresolved Safety Issue" A-43, "Containment Emergency Sump Performance." Its primary purpose is to assess the potential effects of insulation debris generated as the result of a loss-of-coolant accident (pipe break).

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Duke Power Company
Florida Power Corporation
Louisiana Power and Light Company
Maine Yankee Atomic Power Company
Nebraska Public Power District
Public Service Electric and Gas Company
Tennessee Valley Authority
Washington Public Power Supply System

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LIST OF ABBREVIATIONS

ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
B&W	Babcock & Wilcox
BWR	Boiling Water Reactor
CE	Combustion Engineering
CFR	Condensate Filter Demineralizer
CVCS	Chemical and Volume Control System
FPC	Fuel Pool Cooling
GE	General Electric
HPCS	High-Pressure Core Spray
HVAC	Heating, Ventilating and Air Conditioning
LOCA	Loss of Codant Accident
LPCI	Low-Pressure Core Injection
LPCS	Low-Pressure Core Spray
MWe	Megawatt Electrical
NPSH	Net Positive Suction Head
NRC	Nuclear Regulatory Commission
PI	Process Instrumentation
RCB	Reactor Containment Building
RCC	Reactor Closed Cooling
RCIC	Reactor Core Isolation Cooling
RFW	Reactor Feedwater
RHR	Residual Heat Removal
RPV	Reactor Pressure Vessel
RRC	Reactor Recirculation Cooling
RSR	Reactor Safety Research
RWCU	Reactor Water Cleanup
SLC	Standby Liquid Control
SW	Service Water
USNRC	United States Nuclear Regulator Commission
W	Westinghouse
WPPSS	Washington Public Power Supply System

SURVEY OF INSULATION USED IN NUCLEAR POWER PLANTS AND THE POTENTIAL FOR DEBRIS GENERATION

1. INTRODUCTION

The United States Nuclear Regulatory Commission (USNRC) Unresolved Safety Issue A-43, "Containment Emergency Sump Performance," deals with reactor containment building (RCB) emergency sump performance under post loss-of-coolant accident (LOCA) recirculation conditions[1]. This issue describes sump hydraulic performance (i.e., providing adequate net positive suction head to the recirculation pumps) and the effect of insulation debris generated in the course of the LOCA on the performance of the RCB emergency sump and the recirculation pumps.

The NRC Division of Reactor Safety Research (RSR) initiated this study to identify and document the types and amounts of insulation, location within the RCB, components insulated, material characteristics, and methods of installation and attachment at a number of representative plants.

The three basic concerns of the study were:

- Types of insulation used and arrangement of piping within the RCB in the vicinity of pipe breaks in high energy (i.e., primary system) fluid piping postulated for LOCA conditions

- Descriptive details of the insulation used and the type that could be dislodged, thereby becoming a source of debris as the result of a major pipe break

- Location and configuration of the sumps that serve as intakes for the emergency long-term recirculation core cooling, and the communicating paths by which insulation debris generated by a major pipe break could reach the sump

Plant design information was obtained for 11 plants representative of 4 U.S. reactor manufacturers. The selected sample consisted of plants designed by 8 architect-engineering firms for 10 utilities with plant startup dates ranging from 1972 to 1983.

The information for each plant was assembled in a data package that included a preliminary insulation debris hazard analysis. These information packages are included as appendixes in this report.

2. REACTOR PLANTS INVESTIGATED

Table 2-1 lists the plants selected for conducting this generic insulation survey by RSR. Analysis of the design information was performed for all of these plants.

A letter was sent to each utility listing the type of plant design documentation needed for the study. Additional information or clarification was requested by telephone. Two plants were visited to obtain the required information. The information requested was:

- Type and description of thermal insulation used for piping and equipment inside the RCB, including dimensional details
- Specification and contractor details for procurement and installation of insulation in the RCB
- Drawings of installation details of insulation including methods of attaching, spacing, and joining insulation
- Design drawings such as general arrangement drawings of the RCB; structural drawings of the RCB; drawings of all piping inside the RCB including supports, restraints and anchors; flow diagrams of the systems that have piping inside the RCB; drawings that depict the RCB sumps, drainage to the sump, and protection for pump suction intakes; and drainage details in the RCB.

3. TYPES OF INSULATION

Various types of thermal and antisweat insulation are used inside the RCB. Thermal insulation is used for reactor coolant, main steam, feedwater, and emergency core-cooling piping. Antisweat insulation is used for cooling-water, chilled-water, refrigerant, and cold-gas piping.

Types of thermal insulation found in use were:

- Reflective metallic insulation
- Totally encapsulated insulation with different insulation filler types
  - Calcium silicate
  - Expanded perlite
  - Fiberglass
  - Mineral wool fiber
  - Cerablanket
  - Unibestos

Table 2-1. Reactor plants selected for insulation survey

Plant and Location	Reactor	Rating	Startup Date	Utility	Architect-Engineer
Crystal River Unit 3, Red Level, FL	B&W-PWR	825 MWe	1977	Florida Power Corp.	Gilbert
Oconee Unit 3, Seneca, SC	B&W-PWR	860 MWe	1974	Duke Power Co.	Duke Power Co.
Midland Unit 2, Midland, MI	B&W-PWR	805 MWe	1983*	Consumers Power Co.	Bechtel
Maine Yankee, Wiscassett, ME	CE-PWR	790 MWe	1972	Maine Yankee Atomic Power Co.	Stone and Webster
Arkansas Unit 2, Russellville, AR	CE-PWR	858 MWe	1980	Arkansas Power & Light Co.	Bechtel
Waterford Unit 3, Taft, LA	CE-PWR	1165 MWe	1983*	Louisiana Power & Light Co.	Ebasco
Salem Unit 1, Salem, NJ	W-PWR	1090 MWe	1977	Public Service Electric & Gas Co.	Public Service Electric & Gas Co.
Sequoyah Unit 2, Daisy, TN	W-PWR	1148 MWe	1982*	Tennessee Valley Authority	Tennessee Valley Authority
McGuire Units 1&2** Cowans Ford, NC	W-PWR	1180 MWe	1981*	Duke Power Co.	Duke Power Co.
Cooper, Brownsville, NB	GE-BWR-I	778 MWe	1974	Nebraska Public Power District	Burns and Roe
WPPSS Unit 2, Hanford, WA	GE-BWR-II	1150 MWe	1983*	Washington Public Power Supply System	Burns and Roe

* Estimated dates
** Unit 2 estimated startup date is 1983
Source: Nuclear News, February 1981

Mineral fiber blanket metal mesh covered

- Semi-encapsulated insulation
  - Cerablanket (generic)
- Mineral fiber/wool blanket jacketed with asbestos cloth
- Calcium silicate molded block jacketed insulation
- Unibestos or thermobestos molded block jacketed insulation

Types of antisweat insulation found in use were:

- Fiberglass jacketed insulation
- Urethane and polyurethane foam insulation
- Flexible closed-cell rubber insulation

The early use of reflective metallic insulation in the reactor coolant system was limited to the reactor vessel because of the insulation's anticipated long life and the system's inaccessibility once it was installed inside the reactor shield wall. To fulfill the code requirement for inservice inspection of the reactor coolant and emergency core-cooling systems, removable reflective metallic insulation was tried and found satisfactory. Now some newer plants use this type of insulation exclusively in these systems. In addition, totally encapsulated removable insulation is being used in these systems. Mineral fiber blankets, calcium silicate molded blocks, and asbestos were the traditional choices in fossil power plants for high-temperature thermal insulation. Mineral fiber blankets were preferred for valves and equipment where access was needed for maintenance. Asbestos was used for thermal insulation because it is much sturdier than the calcium silicate block that has replaced it in modern stations because of the health hazard properties of asbestos.

Table 3-1 summarizes the types and percentages of each insulation utilized within the primary coolant system shield wall in the 11 plants surveyed. Appendix A describes each type of insulation.

Although some insulation used within the RCB is outside the primary coolant system shield wall, the kind considered significant is that inside the shield wall, because:

- The major portion of the insulation is within the shield wall.
- The location of a piping break that most likely would result in significant debris generation would be within the shield wall.

Table 3-1. Types and percentages of insulation used within the primary coolant system shield wall in plants surveyed

Plant	Types of Insulation and Percentage*					
	Reflective Metallic	Totally Encapsulated	Mineral Fiber/Wool Blanket	Calcium Silicate Block	Unibestos Block	Fiberglass
Crystal River Unit 3	94	5	1	-	-	-
Oconee Unit 3	98	-	-	-	-	2
Midland Unit 2	78	-	-	-	-	22
Maine Yankee	13	-	48	25	13	1
Arkansas Unit 2	46	53	-	-	-	1
Waterford Unit 3	15	85	-	-	-	-
Salem Unit 1	39	8	53**	-	-	-
Sequoyah Unit 2	100	-	-	-	-	-
McGuire Units 1&2	100	-	-	-	-	-
Cooper	30	70	-	-	-	-
WPPSS Unit 2	100	-	-	-	-	-

* Tolerance is ± 20 percent

** Both totally and semi-encapsulated Cerablanket is used, however, inside containment only totally encapsulated is employed.

4. SUMMARY

Table 4-1 shows the types of insulation inside the RCB, the location of the emergency sump, and a summary of the migration potential of debris to cause blockage of the emergency sump as a result of a pipe break for each plant studied. To date, data from 11 plants have been analyzed: 3 Babcock & Wilcox (B&W) units, 3 Combustion Engineering (CE) units, 3 Westinghouse (W) units, and 2 General Electric (GE) units.

B&W Units: In Crystal River Unit 3, it is possible for mineral fiber/wool blanket and totally encapsulated calcium silicate insulation to migrate through the shield wall opening towards the emergency sump. In Oconee Unit 3, reflective metallic insulation could land on the sump gratings and the fiberglass jacketed antisweat insulation could float towards the emergency sump. In Midland Unit 2, mineral fiber/wool jacketed or totally encapsulated fiberglass molded block insulation could migrate through the shield wall openings towards the emergency sump.

CE Units: In Maine Yankee, it is possible for mineral fiber/wool blankets, and totally encapsulated calcium silicate molded block and unibestos molded block insulation to migrate through shield wall openings towards the emergency sump. In Arkansas Unit 2, metal jacketed and totally encapsulated calcium silicate or expanded perlite molded block insulation could float through the shield access opening and migrate towards the emergency sump. In Waterford Unit 3, totally encapsulated fiberglass molded block insulation could float through the large openings in the shield wall and migrate towards the emergency sump.

Westinghouse Units: The Salem Unit 1 emergency sump is covered, and circular trenches around the building feed water into the sump through pipes. It does not appear that insulation debris would pose a problem to the emergency sump. The McGuire Station emergency sump is located outside the primary coolant system shield wall, which is also the crane wall, and reflective metallic insulation is used. This insulation debris will not migrate to the emergency sump because it is heavier than water and will sink. The Sequoyah Unit 2 emergency sump is located inside the primary coolant shield wall, and its piping and equipment use reflective metallic insulation. Gratings are provided by the Tennessee Valley Authority (TVA) to protect the sump against clogging by insulation debris.

GE Units: The flow of pipe break water into the torus/wetwell is unlikely to be blocked off by insulation debris in both the GE units investigated. The intake suction piping is located in the wetwell, and the downcomers are interposed between the debris generation areas and the wetwell. The torus/wetwell in this arrangement performs the function of a sump.

Although the potential for some insulation migration and/or breakup in the vicinity of the sump has been identified for certain plants, this report contains only an initial assessment of debris related questions. Under NRC Contract NRC-04-77-097, Burns and Roe did not undertake any detailed analysis. We understand that NRC plans followup studies to evaluate debris effects.

Table 4-1. Summary Table

Plant and Reactor Manufacturer	Types of Insulation	Location of Emergency Sump	Preliminary Assessment of Migration Potential of Debris Generated as a Result of a Pipe Break
Crystal River Unit 3 (B&W)	Reactor coolant piping, reactor vessel, steam generator, and pressurizer use reflective metallic insulation. Main steam and feedwater piping uses totally encapsulated calcium silicate insulation. Nuclear services cooling water and chemical-cleaning piping, and steam generator use mineral fiber/wool blankets with stainless steel lagging.	Outside the reactor coolant system shield wall below basement floor (see Figure C-2).	Totally encapsulated calcium silicate and mineral fiber/wool blanket insulation could possibly float through the shield access opening and migrate towards the emergency sump. Outside the shield wall, reflective metallic insulation from high energy piping near the emergency sump could fall on the grating.
Oconee Unit 3 (B&W)	Reactor coolant piping, reactor vessel, steam generator and pressurizer, and main steam and feedwater piping use reflective metallic insulation. Low-pressure service water and component cooling lines (to control rod drive service structure) use fiberglass jacketed antisweat insulation.	Inside the reactor coolant system shield wall below basement floor (see Figure D-2).	Reflective metallic insulation from piping in the areas near the sump could land on the grating over the sump and cause some blockage. Also, a substantial quantity of fiberglass jacketed antisweat insulation could fall to the floor and float towards the emergency sump.
Midland Unit 2 (B&W)	Reactor coolant piping, reactor vessel and head, steam generators, and pressurizer surge line use reflective metallic insulation. Reactor coolant pumps, pressurizer, pressurizer spray line, high pressure injection piping, low-pressure injection line, and main steam and feedwater piping use totally encapsulated mineral wool fiber block or fiberglass molded block insulation.	Outside the reactor coolant shield wall below basement floor (see Figure E-2).	Totally encapsulated mineral wool fiber block or fiberglass molded block insulation could possibly float through the shield wall access apertures at basement level (593'6") and migrate towards the emergency sump. The area of totally encapsulated insulation (4400 sq ft) sets 22 percent of the total insulation area within the shield wall area. Lack of covers over the "D" ring areas could permit dislodged insulation debris to come to rest on the grating floor at elevation 685' 0", too high to affect the reactor sump.

Table 4-1. (Continued)

Plant and Reactor Manufacturer	Type of Insulation Utilized	Location of Emergency Sump	Preliminary Assessment of Migration Potential of Debris Generated as a Result of a Pipe Break
Maine Yankee (CE)	Reactor vessel uses reflective metallic insulation. Pressurizer, reactor coolant pumps, and steam generators use calcium silicate molded block jacketed insulation for nonremovable sections and mineral fiber/wool for the removable sections. Primary coolant piping uses removable mineral fiber/wool blankets. Main steam, feedwater, residual heat removal, and chemical and volume control system piping use calcium silicate or unibestos molded block insulation. Component cooling lines use fiberglass jacketed antisweat insulation.	Outside the reactor coolant system shield wall below basement floor (see Figure F-2).	Mineral fiber/wool blanket and calcium silicate or unibestos molded block insulation could float through openings in the shield wall and migrate towards the emergency sump.
Arkansas Unit 2 (CE)	Reactor coolant piping, reactor vessel, bottom head of steam generator, and pressurizer use reflective metallic insulation. Feedwater pressurizer safety relief valve, and balance of steam generator blowdown piping use totally encapsulated calcium silicate or expanded perlite molded block insulation. Main steam piping uses calcium silicate or expanded perlite block with stainless steel jacketing. Chilled water piping uses fiberglass with stainless steel jacketing.	Outside the reactor coolant systems shield wall below basement floor (see Figure G-3).	Molded calcium silicate and/or expanded perlite insulation with stainless steel jacketing could separate. Molded insulation could float through shield access opening and migrate towards the emergency sump. Totally encapsulated insulation could also float towards the emergency sump. Outside the shield wall, no insulated piping is present near the emergency sump.

Table 4-1. (Continued)

Plant and Reactor Manufacturer	Type of Insulation Utilized	Location of Emergency Sump	Preliminary Assessment of Migration Potential of Debris Generated as a Result of a Pipe Break
Waterford Unit 3 (CE)	Reactor vessel uses reflective metallic insulation. Reactor coolant piping, steam generator and pressurizer, main steam and feedwater piping, and all other insulated piping inside containment use totally encapsulated fiberglass insulation.	Outside the reactor system shield wall below basement floor (see Figure H-4).	Totally encapsulated fiberglass insulation could float through the large openings in the shield wall and migrate towards the emergency sump. For piping outside the shield wall, the potential for a large amount of insulation to migrate towards the emergency sump does not exist.
Salem Unit 1 (W)	Reactor vessel, primary coolant piping, pressurizer, reactor coolant pumps, and bottom part of steam generator use reflective metallic insulation. Upper part of steam generator uses semi-encapsulated cerablanket insulation. Main steam, feed water, residual heat removal, safety injection, and chemical and volume and control system piping use totally encapsulated cerablanket. Service water and component cooling-water piping use antisweat insulation.	Outside the reactor coolant system shield wall below basement floor (see Figure I-2). Water drains into emergency sump through trenches in the floor.	Insulation and debris would not pose a problem to the emergency sump.
Sequoyah Unit 2 (W)	All piping and equipment within the shielded crane wall area use reflective metallic insulation.	Inside the crane shield wall below containment floor (see Figure J-2).	A substantial amount of reflective metallic insulation could be blown into the vicinity of the emergency sump. It is not known whether the gratings would adequately prevent blockage with the present information provided by TVA.
McGuire Units 1&2 (W)	Reactor coolant piping, reactor vessel, steam generator, pressurizer, and main steam and feedwater piping use reflective metallic insulation. Refrigerant piping for ice condenser uses urethane insulation.	Outside the reactor system shield and crane wall below the basement floor (see Figure K-1).	Insulation debris would not pose a problem to the emergency sump.

Table 4-1. (Continued)

Plant and Reactor Manufacturer	Type of Insulation Utilized	Location of Emergency Sump	Preliminary Assessment of Migration Potential of Debris Generated as a Result of a Pipe Break
Cooper (GE)	Reactor vessel uses reflective metallic insulation. Recirculation piping uses totally encapsulated unibestos. Main steam piping uses totally encapsulated mineral wool fiber block. Other emergency core-cooling piping uses either totally encapsulated calcium silicate or mineral wool fiber block or reflective metallic insulation. Closed cooling-water and control-air piping use polyurethane antisweat insulation.	Various intake suctions for the emergency core cooling systems are located in the torus of the primary containment (see Figure L-8).	Insulation debris would not pose a problem to the intake suctions of the emergency core cooling systems.
Hanford Unit 2 (GE)	All piping and equipment within the primary containment use reflective metallic insulation.	Various intake suctions for the emergency core cooling systems are located in the wetwells of the primary containment (see Figure M-1).	Insulation debris would not pose a problem to the intake suctions of the emergency core cooling systems.

5. REFERENCE

1. U.S. Nuclear Regulatory Commission, "Containment Emergency Sump Performance," USNRC Unresolved Safety Issue A-43, January 16, 1981. Available in the NRC Public Document Room for inspection and copying for a fee.

APPENDIX A

DESCRIPTION OF INSULATION FOUND IN PLANTS SURVEYED

A description of each type of insulation found from the survey in each of the 11 plants follows.

A. REFLECTIVE METALLIC INSULATION

Metallic all-metal removable insulation is provided primarily by Diamond Power Specialty Company and Transco to the utility industry for the primary coolant system, the reactor vessel, piping and equipment, and American Society of Mechanical Engineers (ASME) Section III Class 2 components and equipment. This type of insulation controls heat loss and enables the owner/operator to comply with the inservice inspection requirements of ASME Code Section XI[1] because it is easily removed. Reflective insulation is constructed in various combinations of materials ranging from all stainless steel to a combination of aluminum and stainless steel. (See Figure A-1.)

The insulation used for piping is typically 2 feet or longer in length, 3 to 4 in. thick, and split into two sections with each section covering half of the pipe. These sections are composed of 24-to 28-gauge stainless steel outer sheets which fully enclose 2 to 6 mil stainless or aluminum sheets. The inner sheets are built up of two to three sheets per inch of insulation thickness. (See Figure A-2.)

The insulation panels used for large equipment such as the reactor vessel, pressurizer, and steam generators are typically 2 by 6 ft and have a construction similar to the insulation described for piping. (See Figures A-3 and A-4.)

All panels on piping and equipment welds that require inservice inspection are fastened by quick release buckle bands for ease of removal. Nonremovable insulation panels are fastened, one to another, with self-tapping screws.

Diamond Power Specialty Company[2] has conducted tests of the response of their reflective insulation to loss-of-coolant accident (LOCA) conditions. Based on these tests, Diamond Power concluded that in a LOCA:

- All-Metal reflective insulation will be crushed instantly near pipe breaks because of the external differential pressure
- All-Metal reflective insulation sections or panels in line with the jet from a pipe break will be blown off the pipe or vessel because of the internal differential pressure that would develop
- All-Metal reflective insulation sections or panels in the immediate vicinity of a pipe break will be transported by the steam or air flow
- All-Metal reflective insulation sections or panels falling into containment will sink rather than be transported because of low velocity to the emergency sump.

B. TOTALLY ENCAPSULATED INSULATION

Diamond Power, Transco, and Johns-Manville produce encapsulated insulation that is used on pressurizers in combination with reflective insulation. The construction of the totally encapsulated modules is exactly the same as that of reflective ones, except that a nonreflective material is used between the inner and outer casings instead of stainless steel. The type of insulation used between the casings for the different plants surveyed was as follows.

Calcium Silicate Molded Block

Calcium silicate molded block insulation is a molded, high-temperature pipe and block insulation composed of hydrous calcium silicate. It is light weight, has low thermal conductivity, and high structural strength, and is insoluble in water. Its density (dry) is 13 to 14 lb. per cubic foot. Its transverse strength (based on 1-1/2 in. thickness) is 35 to 60 psi. Its compressive strength (based on 1-1/2 in. thickness) is 60 to 250 psi. The molded blocks are provided in thicknesses of up to 4 in. and lengths of up to 3 ft. (See Figure A-5.)

Expanded Perlite Molded Block

Expanded perlite molded block insulation is composed of expanded perlite with reinforced mineral fiber and inorganic binders. It is an insulating material with properties similar to those of calcium silicate insulation. The average maximum density is 14 lb. per cubic foot. Its flexural strength should be not less than 35 psi, and its compressive strength dry is 60 psi and wet is 25 psi.

Fiberglass Molded Block

Fiberglass molded block insulation is composed of glass that has been foamed or cellulated under molten conditions, annealed, and set to form a rigid incombustible material with hermetically sealed cells. The density is between 7.0 and 9.5 lb. per cubic foot. Its flexural strength is 60 psi, and compressive strength is 75 psi. The water vapor permeability is 0.005 perm-in. Water absorption is 0.5 percent by volume. (See Figure A-5.)

Mineral Wool Fiber Block

Mineral wool fiber block insulation is made of a mineral substance, such as rock, slag, or glass processed from a molten state into fibrous form. The density, depending on kind, ranges from 10 to 20 lb. per cubic foot. The strength varies considerably with the classes of insulation. The moisture is less than 1.0 percent by volume.

Cerablanket

Cerablanket (trade name), manufactured by Johns-Manville, is a ceramic fibrous insulating material with a density of 6 lb. per cubic foot. The

Cerablanket is enclosed in 0.006 in. metal foil and then encapsulated in a reflective insulation structure.

Unibestos

Unibestos insulation is composed of lime and diatomaceous silica taken from natural deposits. These basic ingredients are bonded with asbestos filber possessing the tensile strength of piano wire. This composition is then encased in stainless steel sheet.

C. SEMI-ENCAPSULATED INSULATION

The construction of semi-encapsulated insulation modules is exactly the same as that of totally encapsulated ones, except that semi-encapsulated modules are assembled in the field and clamped, not welded, together. The type of insulation used between the casings for the different plants surveyed was as follows.

Cerablanket

Cerablanket, as used here, is a generic name indicating unspecified combinations of ceramic, wool, and mineral fiber materials with construction and properties close to those of the Johns-Manville product.

D. MINERAL FIBER BLANKET METAL MESH COVERED

Mineral fiber blanket metal mesh covered insulation consists of blanket thermal insulation covered by flexible metal-mesh facings on one or both sides, and held together by heat-resistant ties extending from one face to the other. Rolls or flat sheets of blanket are usually 4 by 8 ft. with densities between 3 and 12 lb. per cubic foot, and thicknesses of up to 2 in.

E. MINERAL FIBER/WOOL BLANKET JACKETED WITH ASBESTOS CLOTH

Mineral fiber/wool blanket jacketed with asbestos cloth consists of a blanket insulating material of mineral wool or refractory mineral fiber covered with an inner cover of asbestos cloth and an outer cover of fine mesh glass cloth. The density of the blanket material is between 3 and 12 lb. per cubic foot. Blankets are secured with hooks and hog rings.

F. CALCIUM SILICATE MOLDED BLOCK JACKETED INSULATION

Calcium silicate molded block jacketed insulation has been utilized in a number of plants. The jacketing used is fiberglass cloth, stainless steel, or aluminum. Joints are sealed against the entrance of water by sealing compounds. The properties of calcium silicate have been described previously. (See Figure A-6.)

G. UNIBESTOS OR THERMOBESTOS MOLDED BLOCK JACKETED INSULATION

Unibestos, or thermobestos molded block jacketed insulation is composed of lime and diatomaceous silica taken from natural deposits estimated to be millions of years old. These basic ingredients are bonded with asbestos fibers possessing the tensile strength of piano wire. Basically, this type of insulation is calcium silicate held together by asbestos fibers. Since asbestos is now banned for use by the Occupational Safety and Health Act, insulation using this material is no longer manufactured. This insulation is remarkably strong and rigid and, therefore, does not require metal jacketing. It is extremely light, with a density of 11 lb. per cubic foot, and not damaged by water. At some plants, unibestos is used but jacketed with fiberglass cloth or stainless steel sheets. (See Figure A-6.)

H. FIBERGLASS JACKETED INSULATION (ANTISWEAT)

Fiberglass insulation with metal jacketing is a rigid fiberglass pipe insulation made from long, flame-attenuated glass fibers with a thermosetting resin. The polished metal jacket is made of 0.016 in. aluminum or 0.010-in. stainless steel and usually has a longitudinal seam closure that locks the insulation and jacket in place. The insulation with jackets is produced in 3-ft. lengths. The density of the fiberglass ranges from 7.0 to 9.5 lb. per cubic foot.

I. URETHANE AND POLYURETHANE FOAM INSULATION (ANTISWEAT)

Urethane and polyurethane foam antisweat insulation is a rigid cellular foam plastic that combines light weight and strength with exceptional thermal insulating efficiency. The foam is a vast cross-linked network of closed cells, each cell a tiny bubble full of gas that accounts for 90 percent of its volume. Its density ranges from 1.8 to 4.0 lb. per cubic foot. The insulation is sealed with a vapor barrier of aluminum foil or a metal jacket.

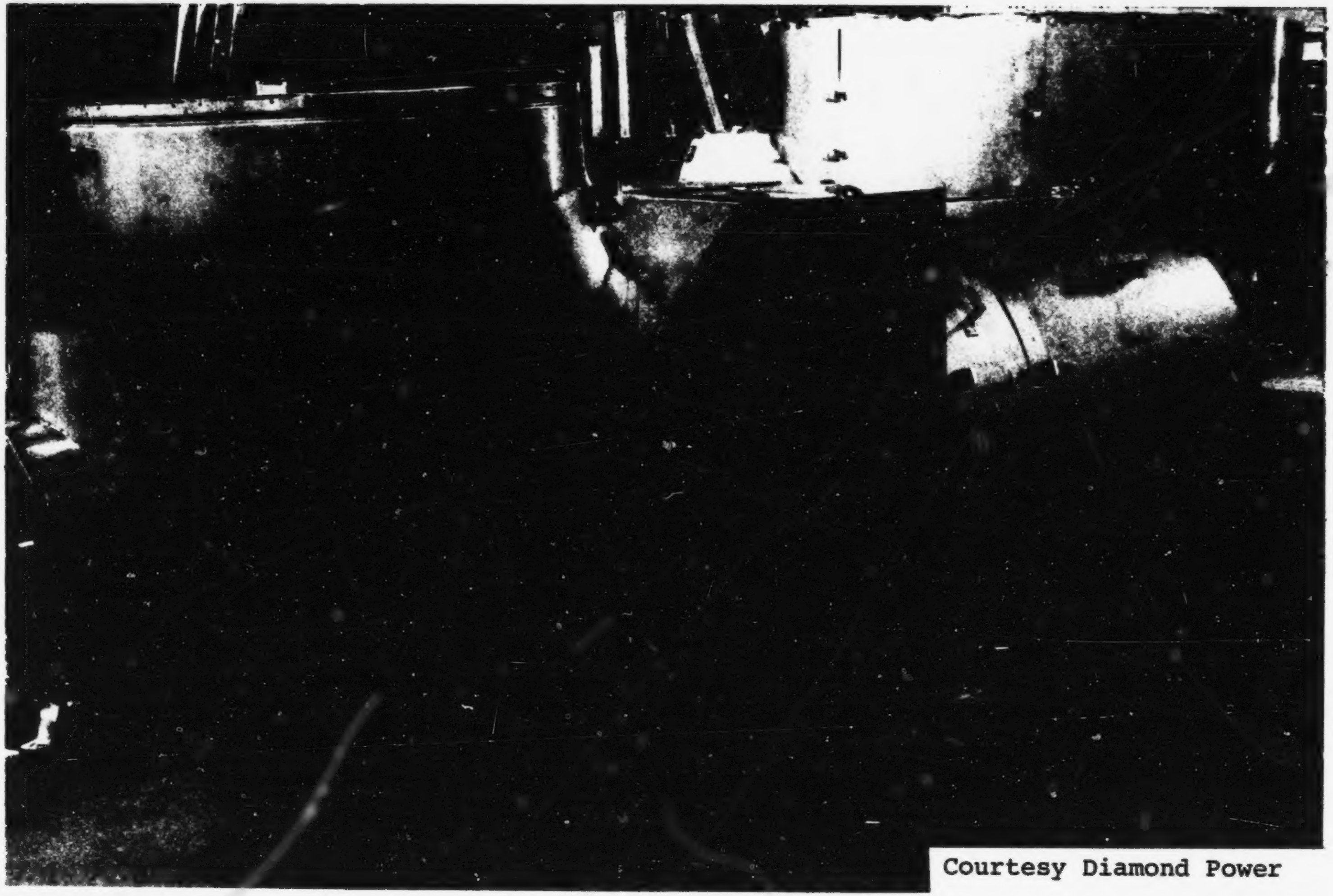
J. FLEXIBLE CLOSED CELL RUBBER INSULATION

Flexible closed cell rubber insulation is a rigid foam rubber that combines light weight and strength with good insulating efficiency. The density is similar to that of urethane insulation. The insulation is sealed with a metal jacket vapor barrier.

K. REFERENCES

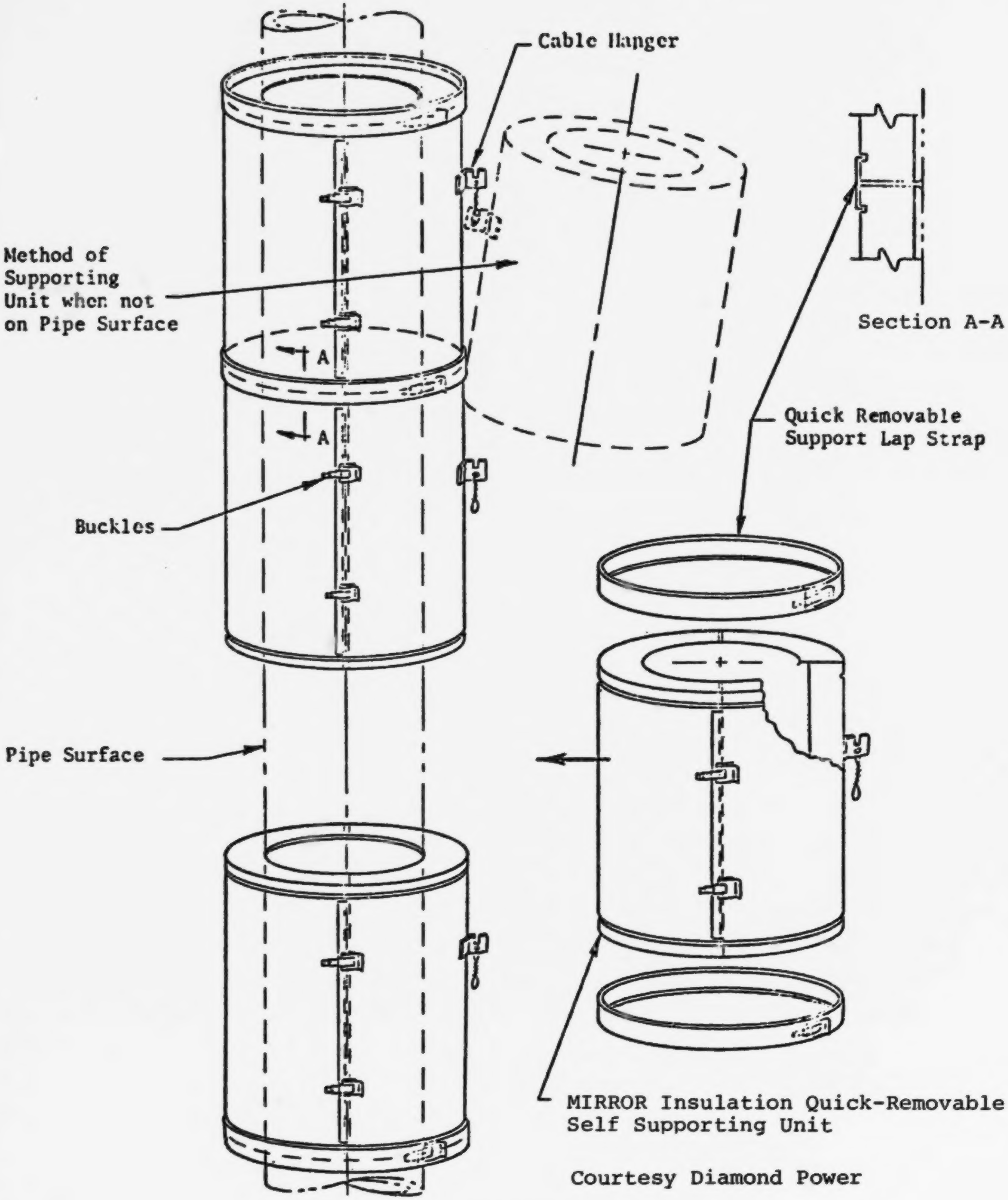
1. ASME Boiler & Pressure Vessel Code, Section XI, 1980," Rules for Inservice Inspection of Nuclear Power Plant Components," ASME, New York, N.Y.

2. Diamond Power Specialty Company, "Response of Mirror Insulation to LOCA Conditions," Diamond Power Specialty Company Report, May 30, 1978.



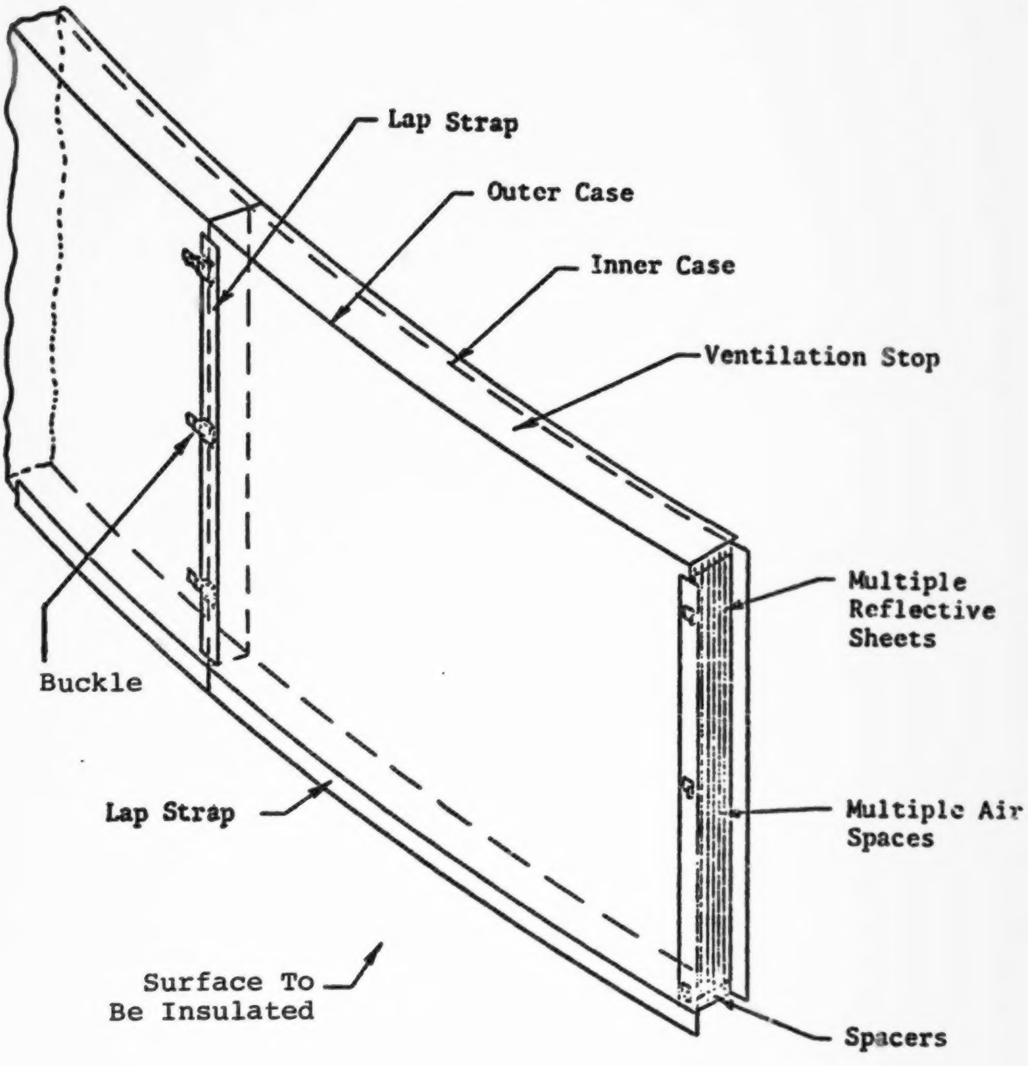
Courtesy Diamond Power

Figure A-1. Specially designed Mirror valve and elbow insulation for 24" residual heat removal at Vermont Yankee Nuclear Station.


Cable Hanger
Method of Supporting Unit when not on Pipe Surface
Section A-A
A
A
Quick Removable Support Lap Strap
Buckles
Pipe Surface
MIRROR Insulation Quick-Removable Self Supporting Unit

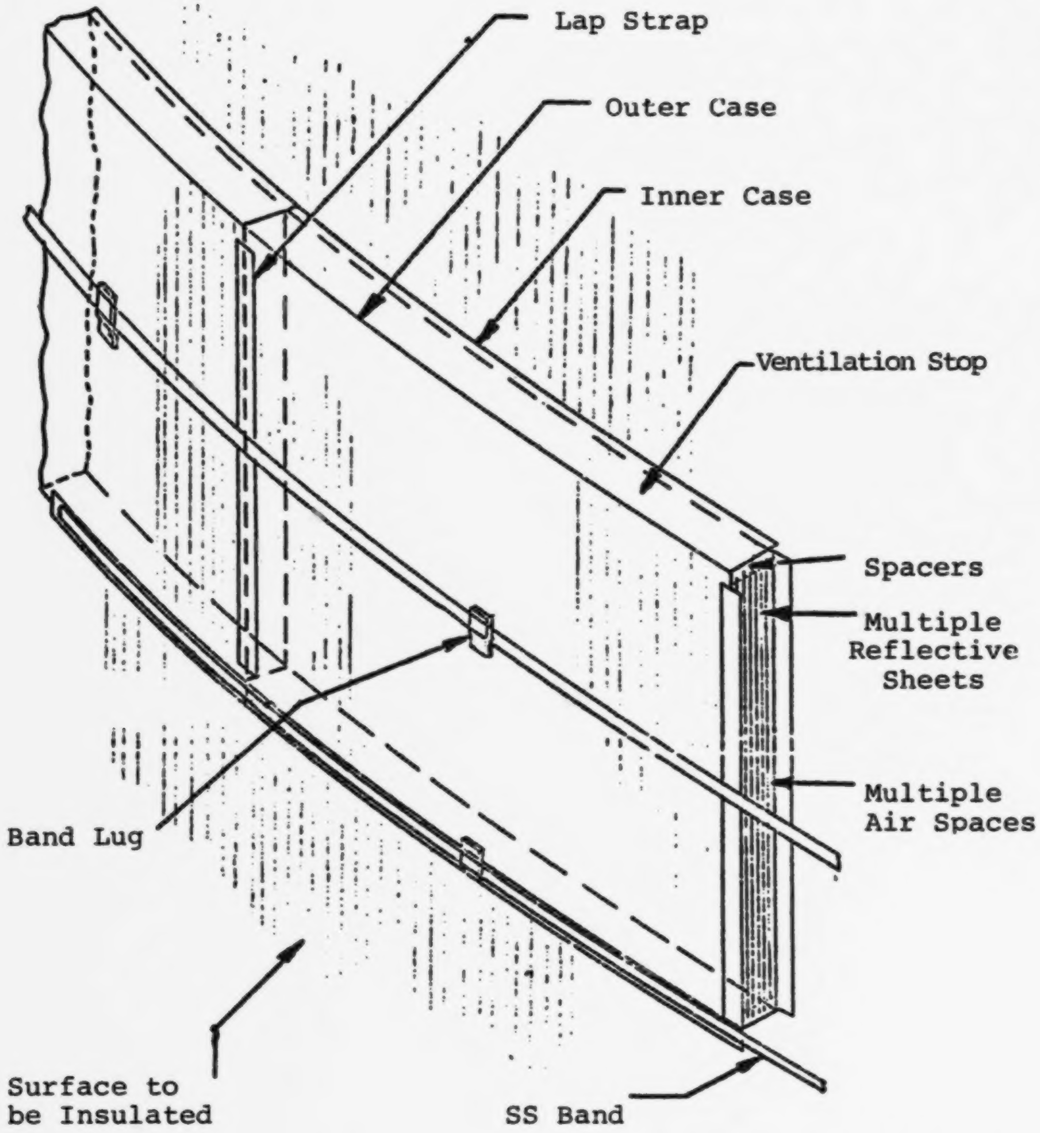
Courtesy Diamond Power

Figure A-2. MIRROR Insulation


Lap Strap
Outer Case
Inner Case
Ventilation Stop
Multiple Reflective Sheets
Buckle
Lap Strap
Multiple Air Spaces
Surface To Be Insulated
Spacers

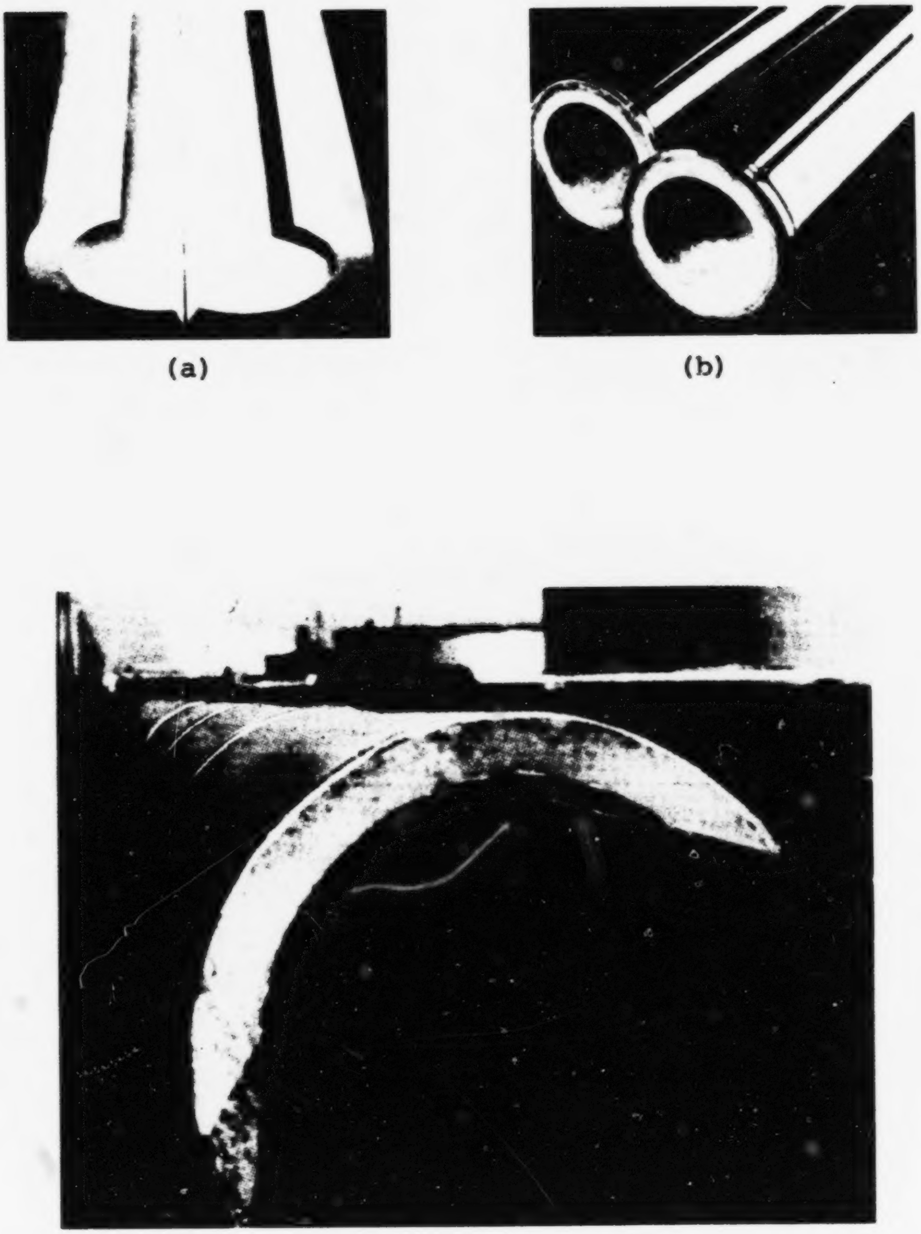
Courtesy Diamond Power

Figure A-3. Typical buckled panel arrangement


Lap Strap
Outer Case
Inner Case
Ventilation Stop
Spacers
Multiple Reflective Sheets
Multiple Air Spaces
Band Lug
Surface to be Insulated
SS Band

Courtesy Diamond Power

Figure A-4. Typical banded panel arrangement



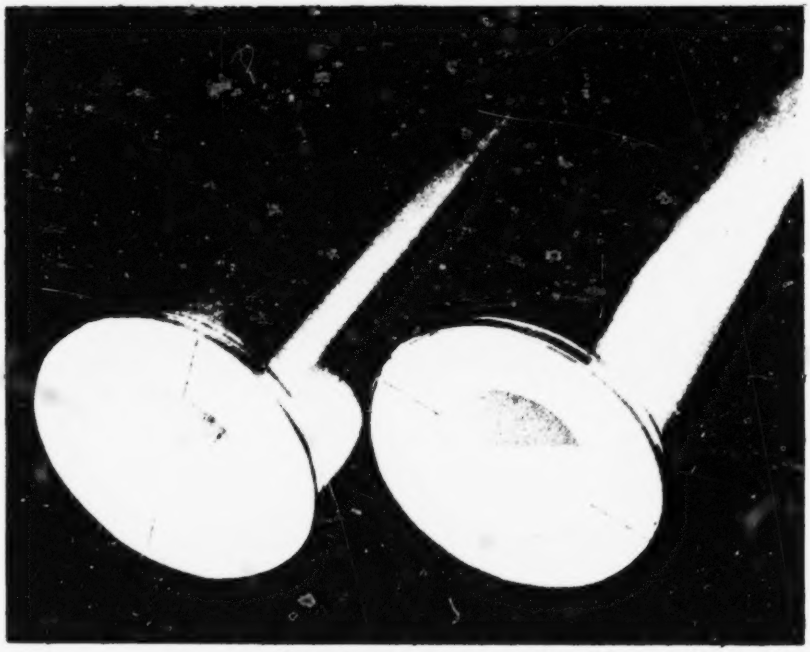
(a)

(b)

(c)

Figure A-5. (a) Calcium silicate molded black insulation;
(b) Figerglass molded block insulation;
(c) Installed calcium silicate insulation.

Courtesy Owens Corning Fiberglas Corp.



Courtesy Owens Corning Fiberglas Corp.

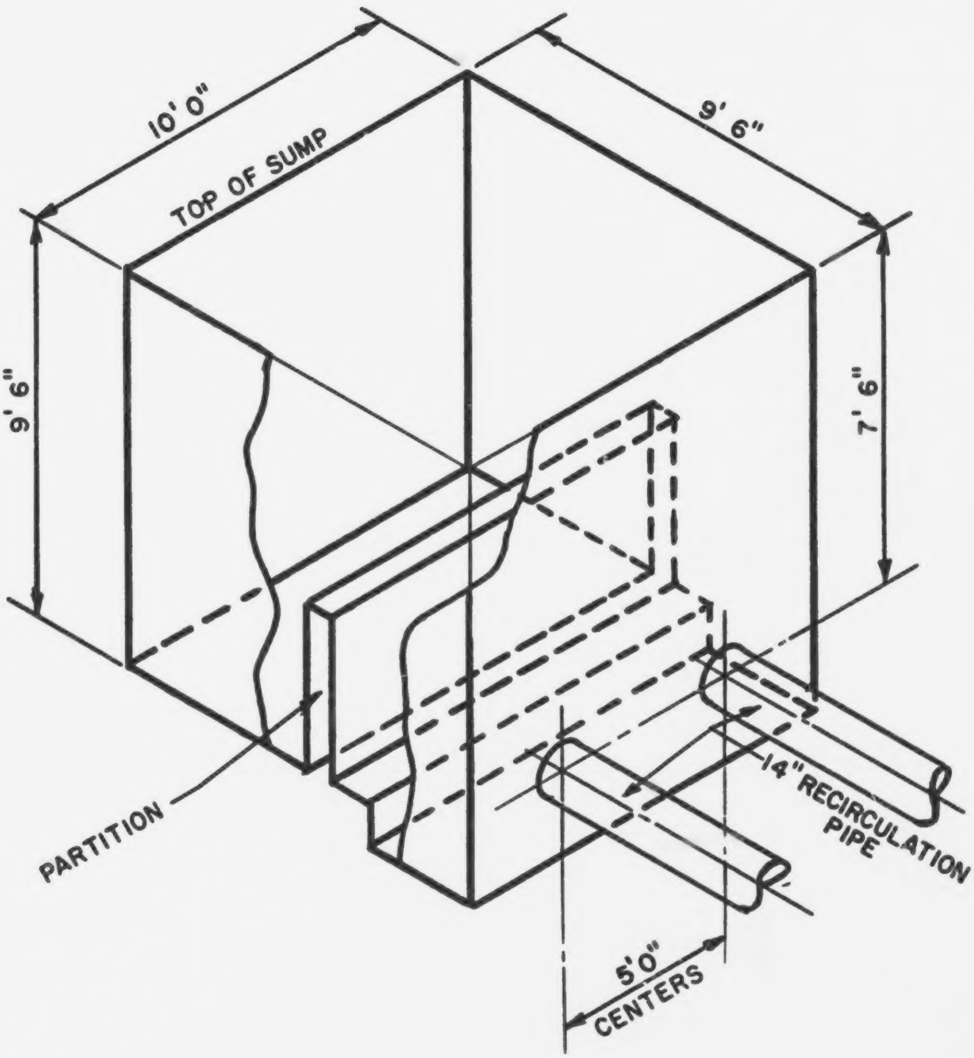
Figure A-6. Calcium silicate or unibestos molded block jacketed insulation

APPENDIX B

EMERGENCY SUMP DIMENSIONS FOR PLANTS SURVEYED

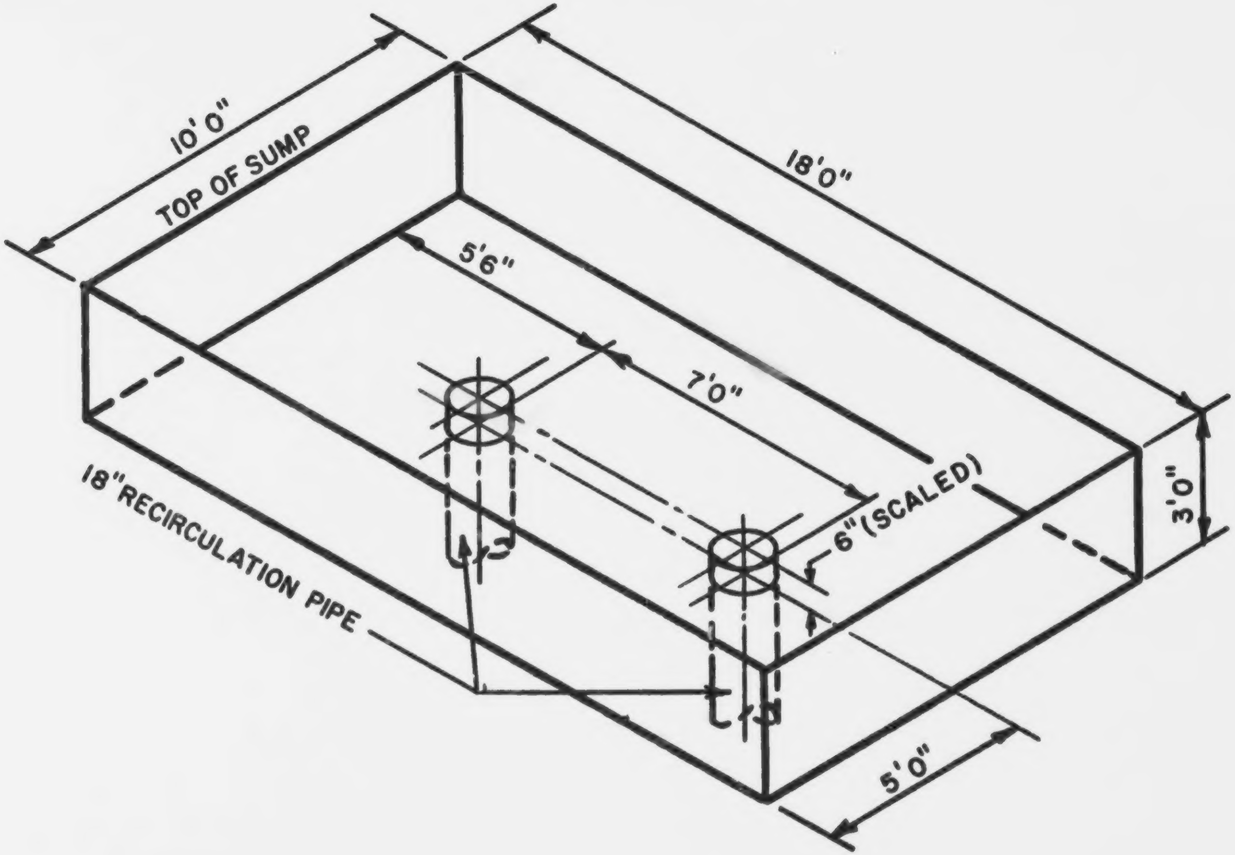
Figure B-1 shows the overall dimensions of the emergency recirculation sumps for the pressurized water reactor (PWR) plants surveyed and includes the location and sizes of recirculation piping. For McGuire Units 1 and 2, see Figures K-2 through K-4.

Sumps are not used in the boiling water reactor (BWR) plants because recirculation piping connections are made in the torus for the Mark I type of containment (Cooper) and in the wetwell for the Mark II type Washington Public Power Supply System (WPPSS).


10' 0"
9' 6"
TOP OF SUMP
9' 6"
7' 6"
PARTITION
14" RECIRCULATION PIPE
5'0" CENTERS

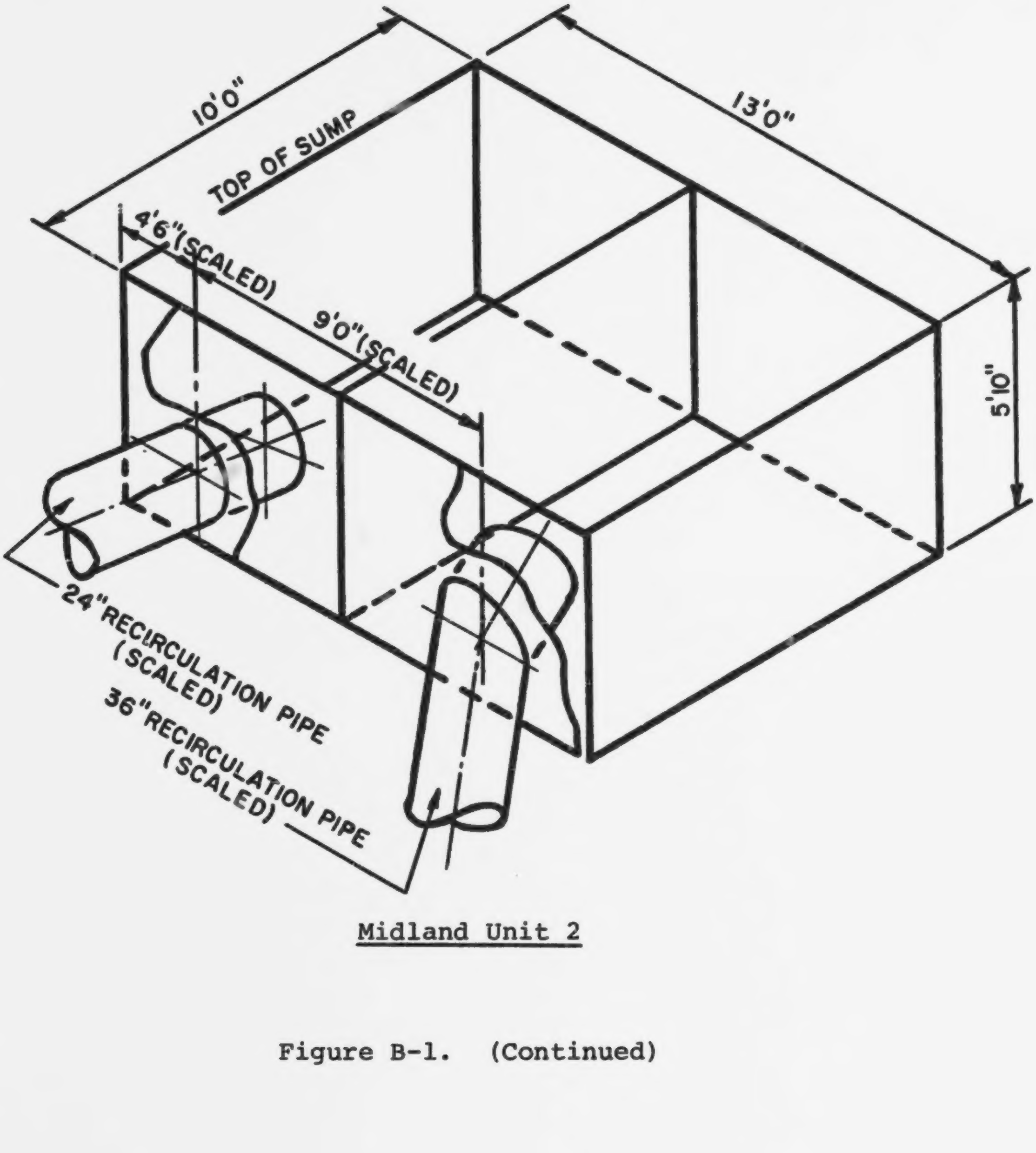
Crystal River Unit 3

Figure B-1. Emergency recirculation sumps and piping for surveyed plants


10'0"
TOP OF SUMP
18'0"
5'6"
7'0"
6"(SCALED)
3'0"
18" RECIRCULATION PIPE
5'0"

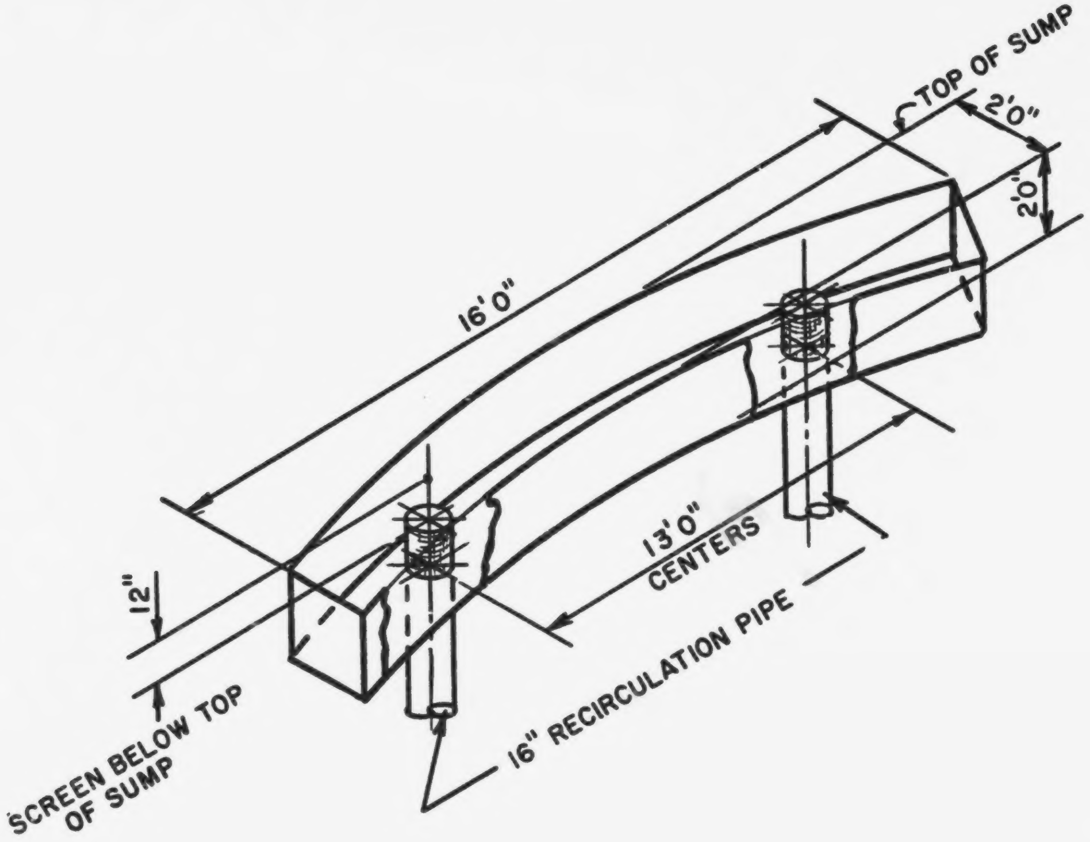
Oconee Unit 3

Figure B-1. (Continued)


10'0"
13'0"
TOP OF SUMP
4'6"(SCALED)
9'0"(SCALED)
5'10"
24"RECIRCULATION PIPE (SCALED)
36"RECIRCULATION PIPE (SCALED)

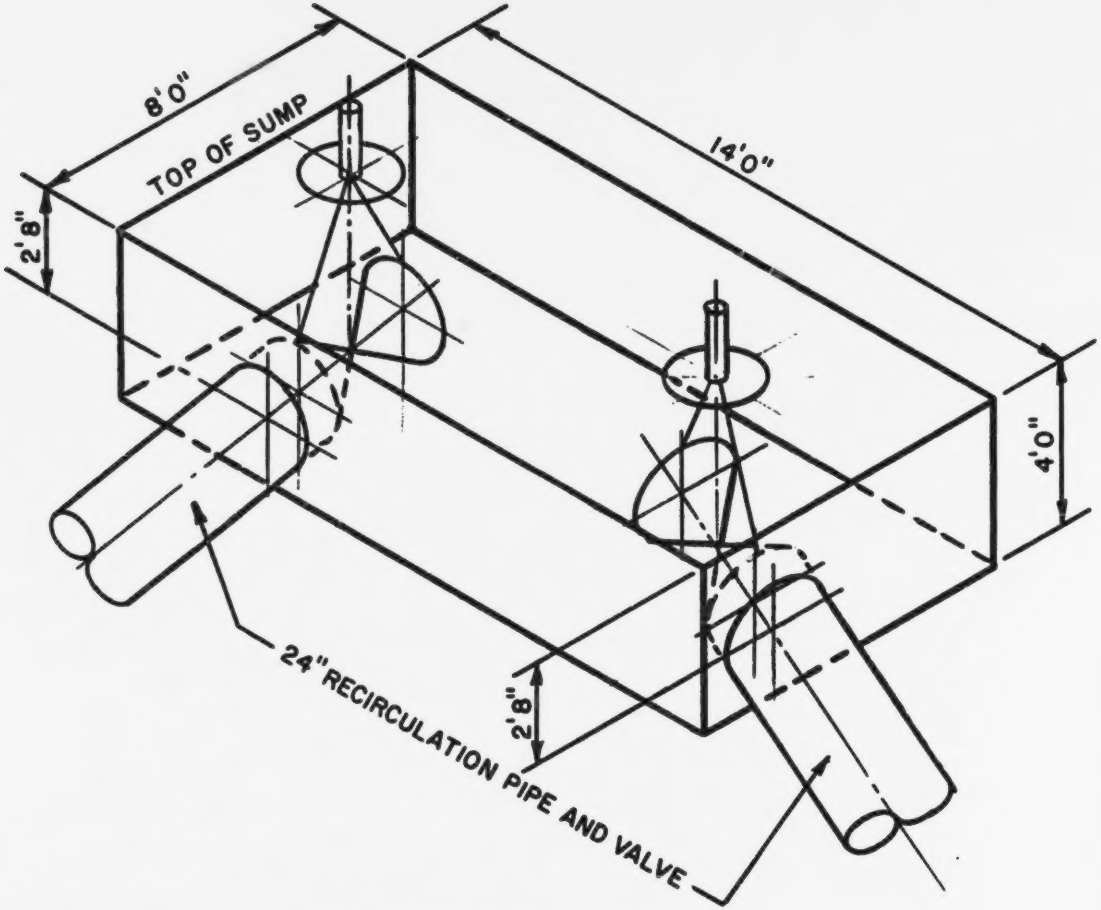
Midland Unit 2

Figure B-1. (Continued)


TOP OF SUMP
2'0"
2'0"
16'0"
13'0"
CENTERS
12"
16" RECIRCULATION PIPE
SCREEN BELOW TOP
OF SUMP

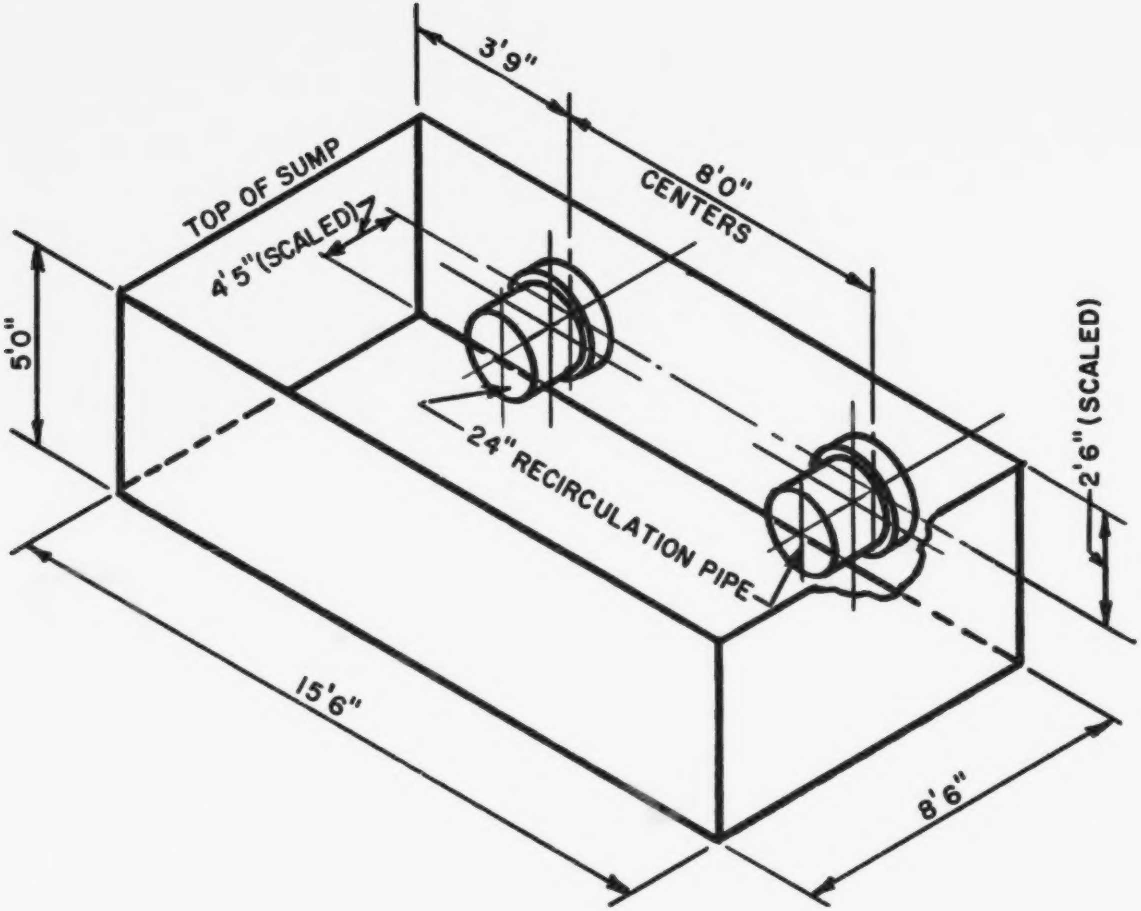
Maine Yankee

Figure B-1. (Continued)


8'0"
TOP OF SUMP
14'0"
2'8"
4'0"
2'8"
24" RECIRCULATION PIPE AND VALVE

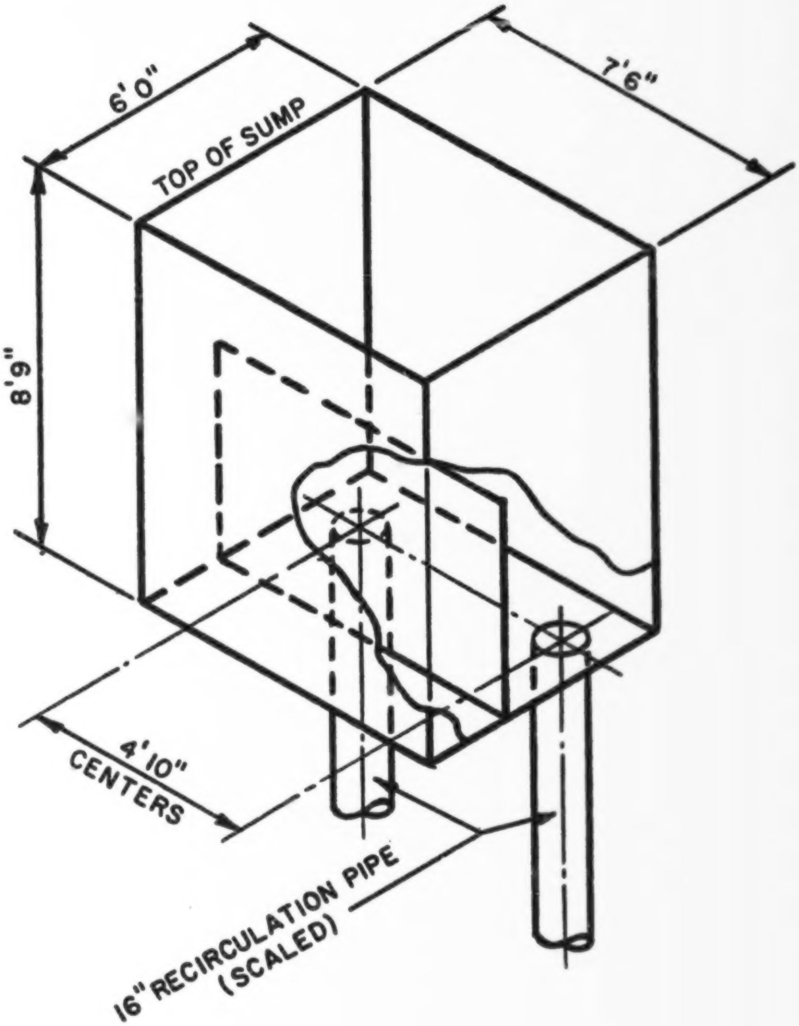
Arkansas Unit 2

Figure B-1. (Continued)


3'9"
8'0"
CENTERS
TOP OF SUMP
4'5"(SCALED)
5'0"
24" RECIRCULATION PIPE
2'6"(SCALED)
15'6"
8'6"

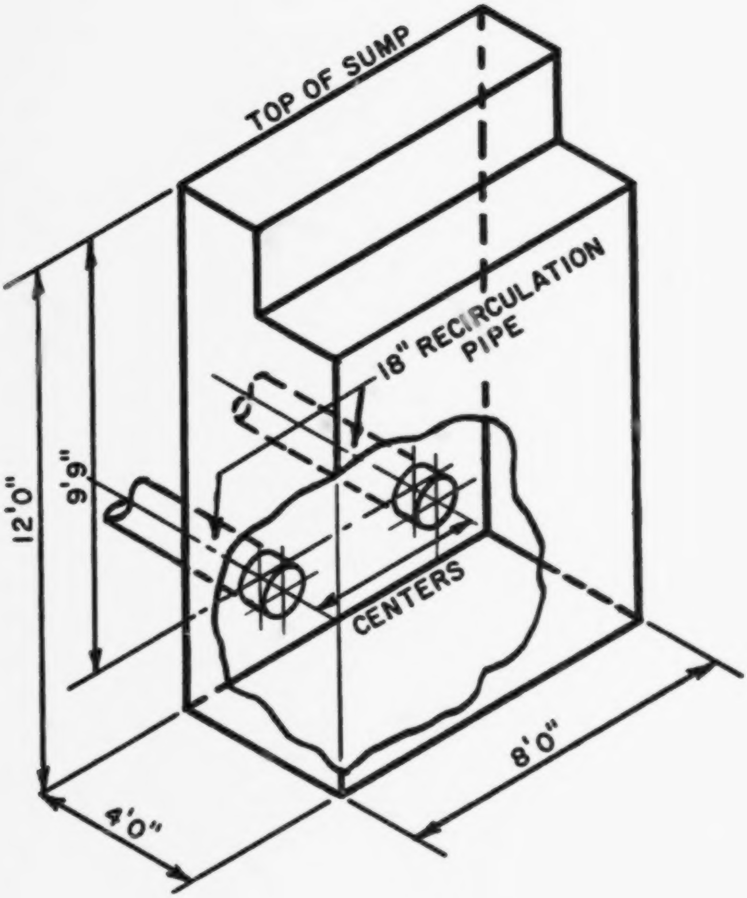
Waterford Unit 3

Figure B-1. (Continued)


6'0"
7'6"
TOP OF SUMP
8'9"
4'10"
CENTERS
16" RECIRCULATION PIPE
(SCALED)

Salem Unit 1

Figure B-1. (Continued)


TOP OF SUMP
18" RECIRCULATION PIPE
12'0"
9'9"
CENTERS
8'0"
4'0"

Sequoyah Unit 2

Figure B-1. (Continued)

APPENDIX C

CRYSTAL RIVER UNIT 3:

PRELIMINARY ASSESSMENT OF INSULATION DEBRIS GENERATED DURING A PIPE BREAK EVENT

A. INTRODUCTION

This report documents and analyses the information gathered by Burns and Roe's survey of thermal insulation used inside the reactor containment building (RCB) of the 825 MWe, Babcock & Wilcox PWR, Crystal River Unit 3 which began commercial operation in 1977.

The information gathered depicts the following:

1. The arrangement of all piping within the RCB including high energy piping
2. The location and configuration of the emergency intake sump for emergency core cooling and the communicating paths by which debris generated by a major pipe break could reach the emergency recirculating sump
3. Details of the insulation that could be dislodged and become a source of debris as a result of a major break

According to the information provided by Florida Power Corporation, reflective metal insulation is used for all primary coolant piping and equipment within the reactor and steam generator shielded walls, and all removable sections within the RCB. Totally encapsulated insulation is used for the main steam, feedwater, and emergency feedwater lines from the steam generator connection to the respective containment penetration.

B. LISTING OF INPUT DRAWINGS AND OTHER DOCUMENTS

This section provides a listing of drawings and documents showing details of the containment and reactor building, emergency sump details, flow diagrams for insulated systems inside containment, piping layout drawings for systems inside containment, reactor building equipment and equipment insulation drawings, reactor building heaters, ventilation, and air conditioning (HVAC) drawings, and reactor building cable tray drawings.

1. Documentation

   - Specification SP-5903 — Insulation Inside Reactor Building

2. Drawings

   a. General Arrangement - Containment and Reactor Building

L-001-012	Layout Above Reactor, Auxiliary and Intermediate Building Basement Floor El. 75'-0" & 95'-0"
L-002-002	Layout Cross Section Through Reactor Building and Auxiliary Building

L-001-023	Layout Plan Above Reactor and Auxiliary and Intermediate Buildings El. 143'-0"
L-001-032	Layout Plan Above Reactor Building El. 162'-0"
L-001-042	Layout Plan Above Reactor Building El. 180'-0"
BS-311-730	Reactor Building Sections
BS-311-729	Reactor Building Sections

b. Emergency Sump Design Details

Figure 6-3B	Reactor Building Sump
FSAR	Screen Assembly

c. Flow Diagrams for Systems Inside Containment

IN-313-826	Reactor Building Penetration Cooling
IN-313-711	Reactor Building Spray
IN-313-702	Core Flooding System
IN-313-661	Makeup & Purification
IN-313-651	Reactor Coolant
IN-313-641	Decay Heat Removal
IN-313-601	Nuclear Services Closed Cycle Cooling
IN-313-192	Chemical Cleaning Steam Generators
IN-313-113	Feed Water Heater Reliefs Vents & Drains
IN-313-081	Feedwater

d. Piping Layout Drawings for Systems Inside Containment

P-304-608	Nuclear Services Closed Cycle Cooling System Sections Reactor Building

P-304-609	Nuclear Services Closed Cycle Cooling System Sections Reactor Building
P-304-674	Liquid Sampling Plan and Sections Reactor Building
P-304-654	Reactor Coolant System - Drains Plan and Sections Reactor Building
P-304-652	Reactor Coolant System Vents and Drains Plans and Sections Reactor Building
P-304-651	Reactor Coolant Pressurizer Safety Valve Escape Piping Plans and Sections
P-304-667	Makeup and Purification System H.P. Injection and Letdown Cooling Plan and Sections -Reactor Building
P-304-084	Feedwater Sections Intermediate and Reactor Buildings
P-304-085	Emergency Feedwater Plan Below El. 160'-0" Intermediate and Reactor Buildings
P-304-086	Emergency Feedwater Sections Intermediate and Reactor Buildings
P-304-193	Chemical Cleaning Steam Generators Plans and Sections - Intermediate Building
P-304-192	Steam Generator Chemical Cleaning Plan Above El. 119'-0" and Sections - Reactor Building
P-304-191	Steam Generator Chemical Cleaning Plan Above El. 94'-0" and Sections - Reactor Building
P-304-666	Makeup and Purification System Plan Above El. 110'-0" - Reactor Building
P-304-668	Makeup and Purification System Sections - Reactor Building

P-304-644	Decay Heat Removal Plan and Sections Reactor Building
P-304-702	Core Flooding System 2" Pipe and Smaller Inside Reactor Building Plan and Sections
P-304-703	Core Flooding System Plan and Section
P-304-653	Reactor Flange Leak Detection and Gasket Drain Thru Primary Shield Wall
P-304-647	Reactor Building Recirculation Line "B" Plan and Sections

e. Reactor Building Equipment and Equipment Insulation Drawings

BS-312-601	Reactor Coolant Drain Tank 8'-6" Dia. x 13'-2" Str. Shell
143275E	Steam Generator
0426-001	Primary Coolant Pump
0426-002	Reactor Coolant Pump
134917 E	Assembly and Detail of Lower Head
134916 E	Assembly and Detail of Upper Head
620-0007-59	Pressurizer As-Built Drawing
142826	Arrgt. of Core Flooding Tank
163372	Reactor Vessel Free-Standing Thermal Insulation Arrangement
51-42-007-01	Vessel Insulation Development
51-42-009-02	Mirror Insulation Outline Dimensions
51-42-012-00	"GH" Arrgt and Section Views
135558 E	Reactor Vessel Insulation Supports
51-42-001-00	Mirror Insulation Outline Dimensions
51-42-005-01	Vessel Skirt Insulation Arrangement

51-42-008-02	Vessel Insulation Access and Inspection Panels Arrangement

f. Reactor Building HVAC Drawings

BS-311-790	Reactor Building Ventilation Duct Supports
BS-311-728	Reactor Building Plan Below Crane Rail
BS-311-727	Reactor Building Plan at Floor El. 180'-6"
BS-311-726	Reactor Building Plan at Floor El. 119'-0"
BS-311-744	Penetration Cooling System Plans, Sections and Details

g. Reactor Building Cable Tray Drawings

E-214-051	Electrical Cable Trays Reactor and Intermediate Building Above El. 95'-0"
E-214-053	Electrical Cable Trays Reactor Building Above El. 160'-0"
E-214-152	Electrical Cable Tray Hangers - Reactor and Intermediate Building El. 119'-0"
E-214-151	Electrical Cable Tray Hangers - Reactor and Intermediate Building Above El. 95'-0"

B. LISTING OF PIPING INSIDE CONTAINMENT CONTAINING INSULATION

This section provides a list of the piping systems inside the RCB that are insulated. The list includes the system, nominal pipe sizes inside containment, and the type of insulation used for each system.

System	Nominal Pipe Sizes (inches)	Type of Insulation
Reactor coolant	36, 28	Reflective metallic
Core flooding	14	Reflective metallic
Pressurizer surge line	4, 2-1/2	Reflective metallic
Main steam		Totally encapsulated
Feedwater		Totally encapsulated
Decay heat removal	10, 2	Reflective metallic
Makeup & purification	3, 2-1/2, 3/4	Reflective metallic

Nuclear services closed cycle cooling	8, 6, 5	Blanket type
Chemical cleaning (steam generator)	10, 4, 1-1/2	Blanket type

D. TYPICAL INSULATION DETAILS

Reflective metallic insulation is used for the reactor vessel, steam generators, pressurizer, primary pumps, and all reactor coolant piping inside containment. The reflective insulation is similar to that described in Appendix A of this report. The insulation contractor is Mirror Insulation, a unit of Diamond Power Specialty Company. The reflective insulation is constructed of stainless steel.

Totally encapsulated calcium silicate insulation is used for the main steam, feedwater, and emergency feedwater piping outside containment. The construction of the encapsulated insulation is exactly the same as that of the reflective type, except that a nonreflective insulation is used between the inner and outer stainless steel casings.

The nuclear services closed cycle cooling and chemical cleaning piping for the steam generator are covered with mineral fiber/wool blanket with stainless steel lagging.

Vendor drawings of piping insulation were not submitted by Florida Power Corporation.

E. PIPE BREAK LOCATIONS

Refer to the final safety analysis report (FSAR)1 for a list of the pipe break locations for high energy piping inside the primary containment.

F. FSAR REFERENCES ON PERTINENT INSULATION QUESTIONS

None were submitted by Florida Power Corporation

G. PRELIMINARY INSULATION DEBRIS HAZARD ANALYSIS

Figures C-1, C-2, and C-3 are simplified sketches of the Crystal River Unit 3 reactor containment. The reactor vessel, steam generators, pressurizer, and associated piping are located inside the shield wall. The emergency sump is located outside the shield wall below the basement floor at elevation 95' as shown in Figure C-2. Figure C-4 shows the details of the emergency sump. The sump contains the reactor building sump pumps as well as the suction piping for the emergency core cooling system. Water enters the sump at the floor elevation through a 1-1/2" grating. The recirculation suction piping is protected from debris by a debris hopper and a screen in the sump. The 1-1/2 in. grating cover above the sump inlet is designed to prevent large debris from entering the sump area. Dislodged debris and paint chips present in the recirculation water, smaller than 1-1/2" in size, will flow into the reactor building sump through the sump screen assembly. The sump screen will screen out particles 1/4" and larger. Debris (encapsulated mineral wool blanket insulation) resulting from a pipe break within the shield wall could possibly float through the shield access opening and migrate towards the emergency sump. Any dislodged reflective insulation would sink to the floor of the containment if blown off the piping.

Outside the shield wall are a number of high energy pipes located in the vicinity of the emergency sump. These are the 2-1/2 in. makeup water pipes, 10 in. decay heat pipes, and 14 in. core flooding pipes. These pipes are insulated with reflective metallic insulation, which could become dislodged in the event of the pipe break, and fall and land on the grating of the emergency sump.

H. REFERENCE

1. Crystal River 3, Final Safety Analysis Report, Florida Power Corporation, St. Petersburg, Florida.

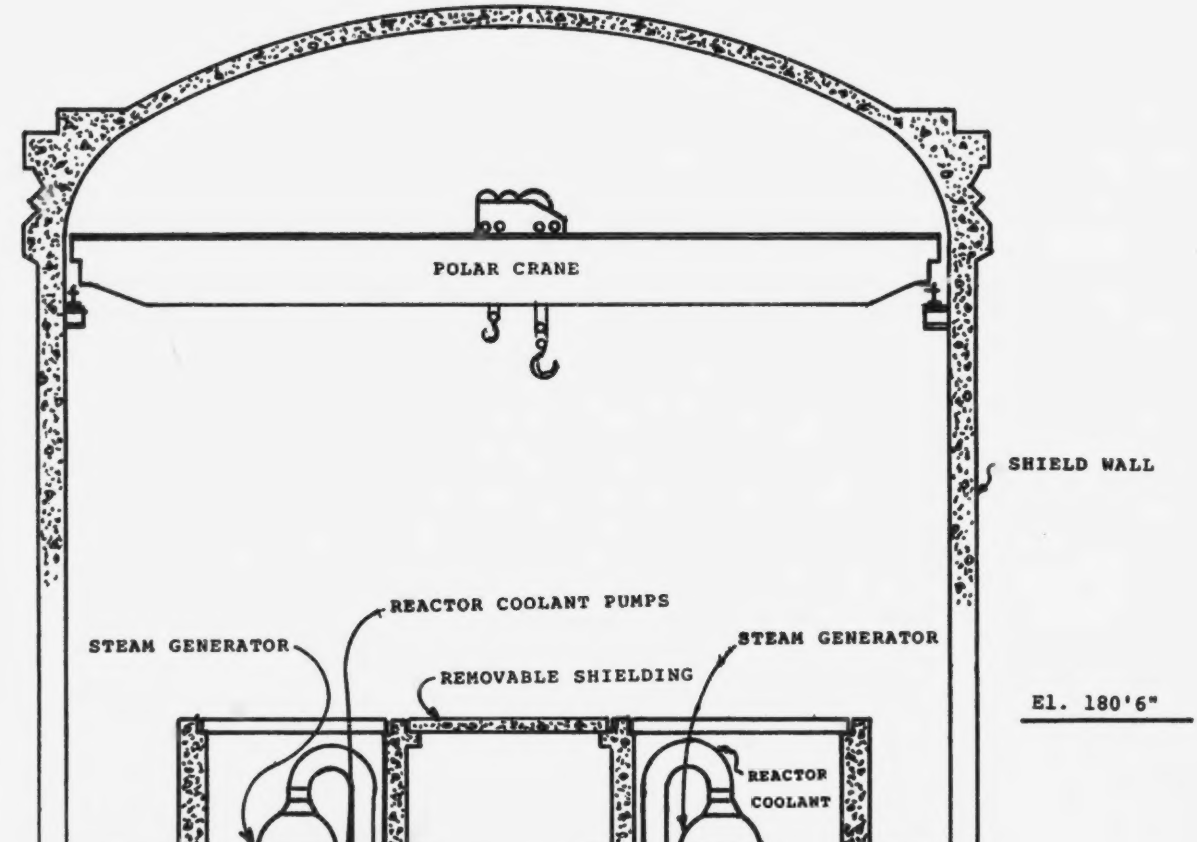
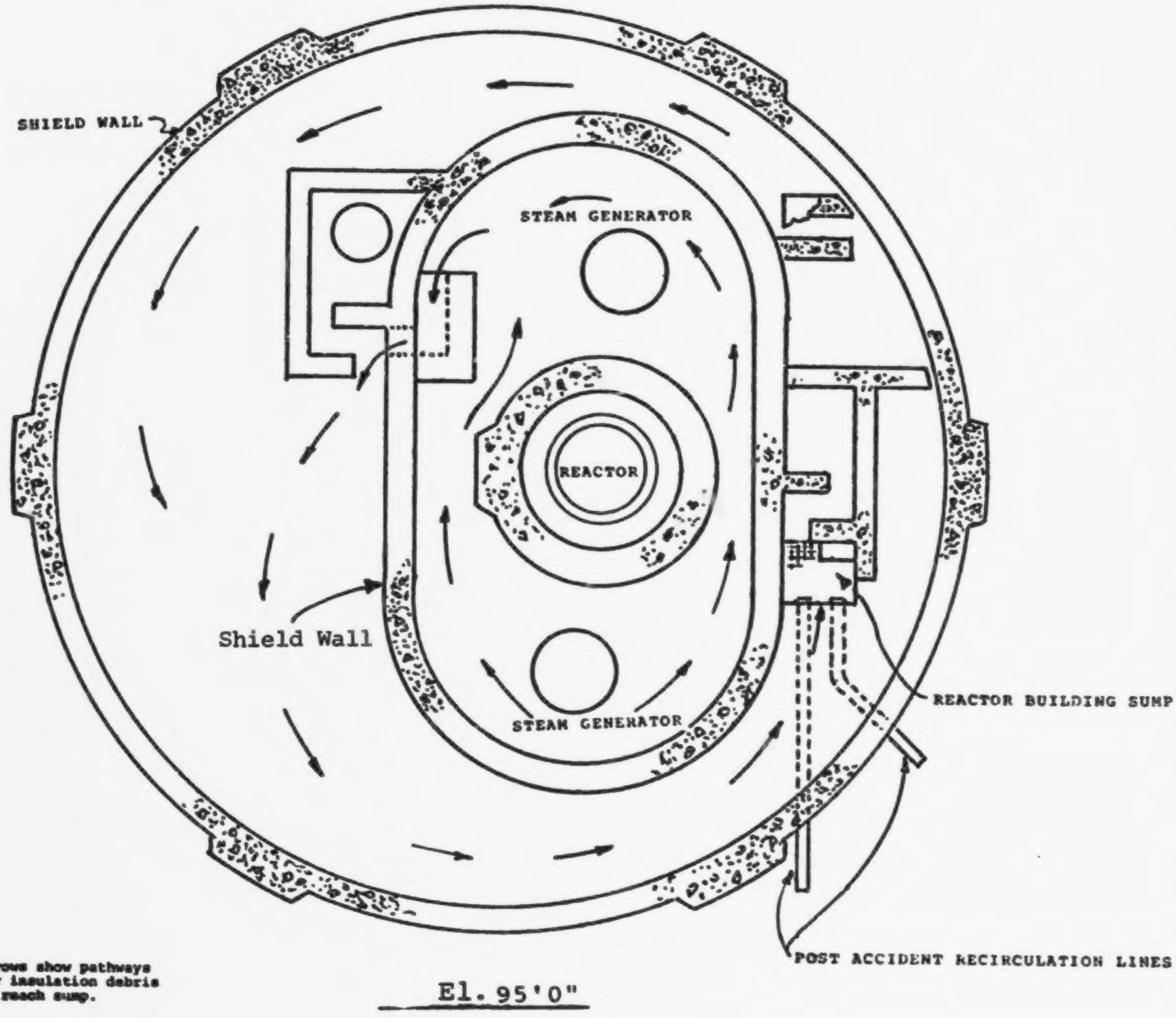

POLAR CRANE
SHIELD WALL
REACTOR COOLANT PUMPS
STEAM GENERATOR
STEAM GENERATOR
REMOVABLE SHIELDING
El. 180'6"
REACTOR COOLANT
FEEDWATER PIPING
REACTOR
El. 95'0"

Figure C-1. Reactor containment arrangement, Crystal River Unit 3


SHIELD WALL
STEAM GENERATOR
REACTOR
Shield Wall
STEAM GENERATOR
REACTOR BUILDING SUMP
POST ACCIDENT RECIRCULATION LINES
El. 95'0"
SCALE
0
25'
50'

NOTE: Arrows show pathways for insulation debris to reach sump.

TYPE OF INSULATION INSIDE PRIMARY COOLANT SYSTEM SHIELD WALL	APPROXIMATE QUANTITY FT^2
Reflective Metallic	12,500
Encapsulated Fiberglass	715
Mineral Wool Blanket	150

Figure C-2. Reactor containment, Crystal River Unit 3

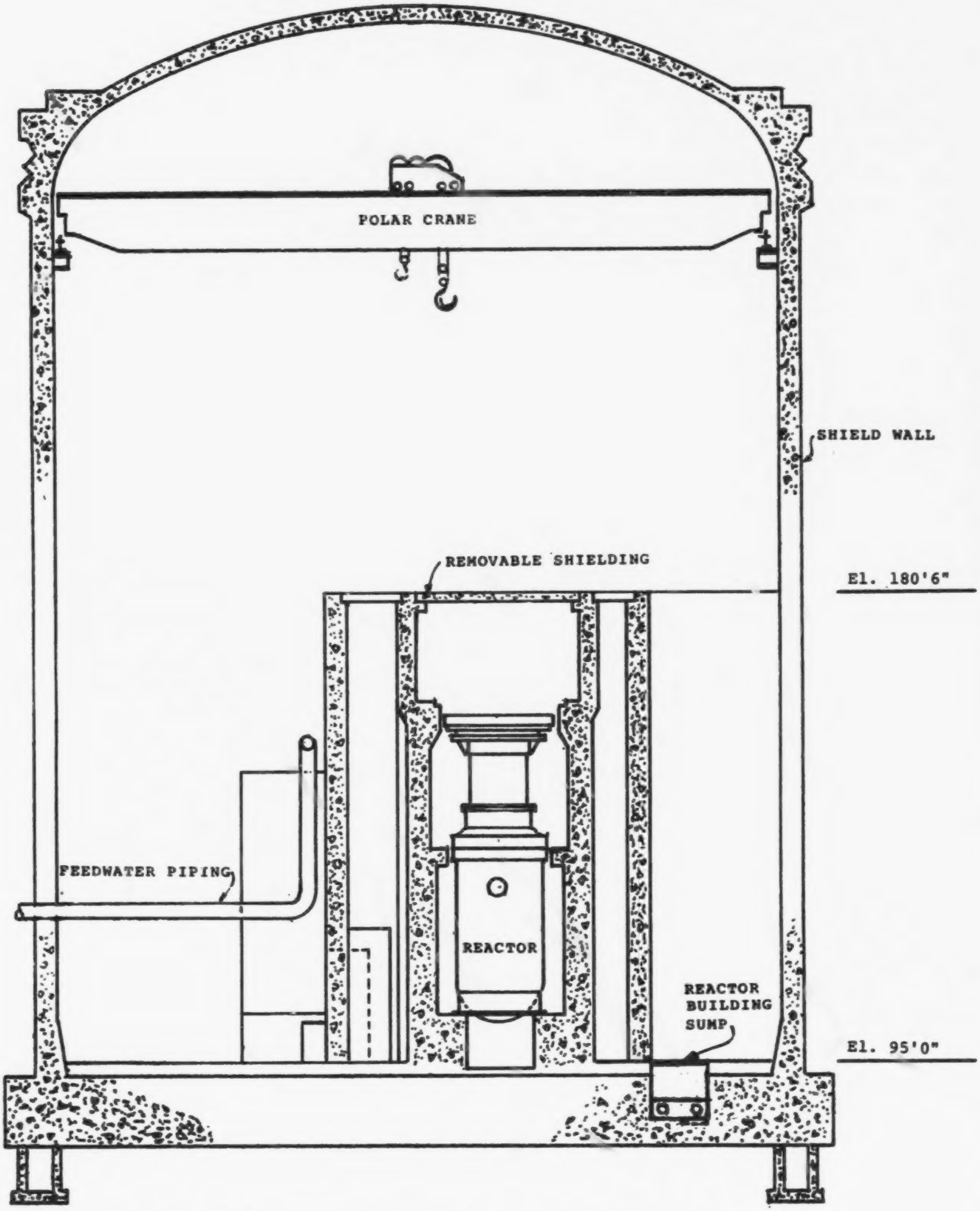
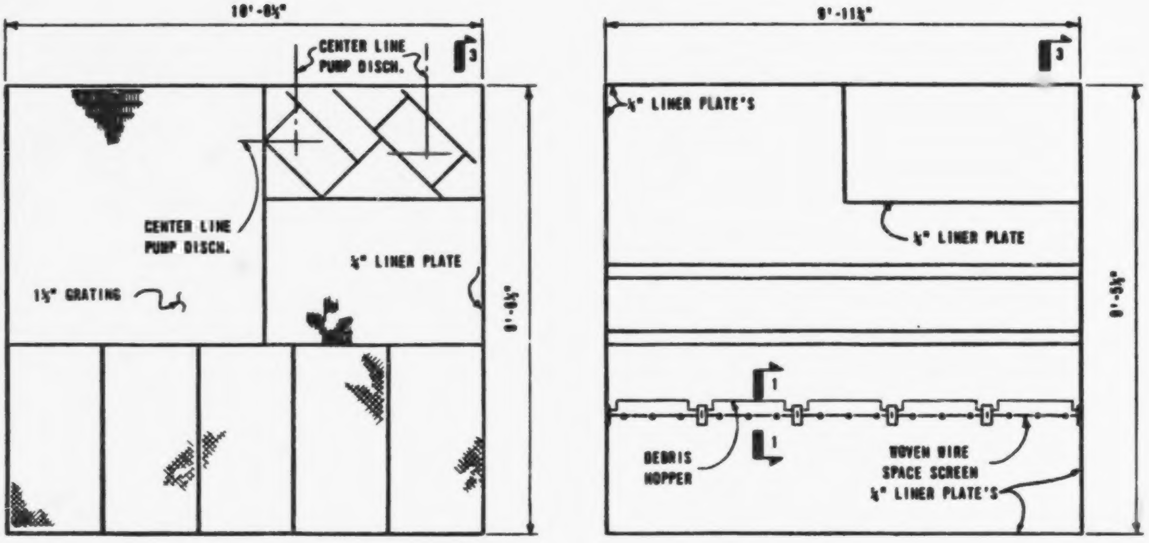
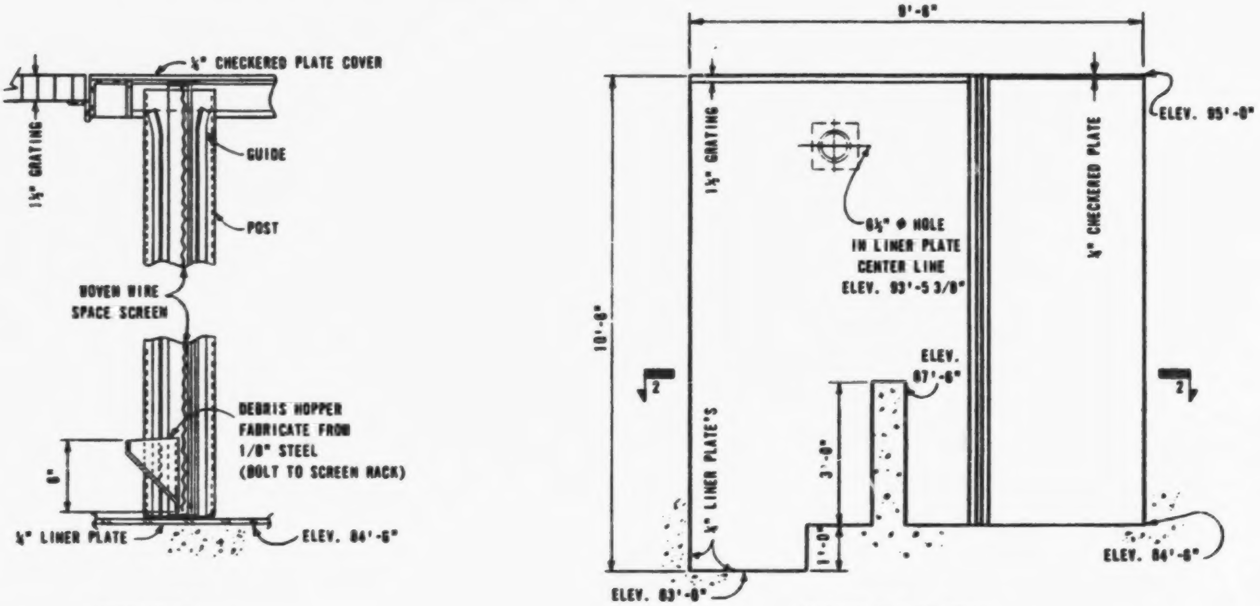

POLAR CRANE
SHIELD WALL
REMOVABLE SHIELDING
El. 180'6"
FEEDWATER PIPING
REACTOR
REACTOR
BUILDING
SUMP
El. 95'0"

Figure C-3. Primary containment, Crystal River Unit 3


10'-8½"
CENTER LINE PUMP DISCH.
3
CENTER LINE PUMP DISCH.
¼" LINER PLATE
1½" GRATING
9'-8½"
9'-11½"
3
¼" LINER PLATE'S
¼" LINER PLATE
9'-5½"
1
1
DEBRIS HOPPER
WOVEN WIRE SPACE SCREEN
¼" LINER PLATE'S
3
3

PLAN
STEEL LINER AND SUMP COVER AT ELEV. 95'-0"

SECTIONAL PLAN 2-2


¼" CHECKERED PLATE COVER
1½" GRATING
GUIDE
POST
WOVEN WIRE SPACE SCREEN
DEBRIS HOPPER FABRICATE FROM 1/8" STEEL (BOLT TO SCREEN RACK)
6"
¼" LINER PLATE
ELEV. 84'-6"
9'-8"
ELEV. 95'-0"
1½" GRATING
¼" CHECKERED PLATE
6½" Φ HOLE IN LINER PLATE CENTER LINE ELEV. 93'-5 3/8"
10'-0"
2
2
ELEV. 87'-6"
3'-0"
¼" LINER PLATE'S
1'-0"
ELEV. 84'-6"
ELEV. 83'-0"

SECTION 1-1

SECTION 3-3 AS SHOWN

Courtesy Florida Power Corp.

Figure C-4. Reactor building pump screen assembly, Crystal River Unit 3

APPENDIX D

OCONEE UNIT 3:

PRELIMINARY ASSESSMENT OF INSULATION DEBRIS GENERATED DURING A PIPE BREAK EVENT

A. INTRODUCTION

This report documents the information gathered by Burns and Roe's survey of thermal insulation inside the primary containment of the 860 MWe, Babcock & Wilcox, PWR Oconee Unit which began commercial operation in 1974.

The information gathered depicts the following:

1. The arrangement of all piping within the primary containment including high energy fluid piping
2. The location and configuration of the emergency intake sump for emergency core cooling, and the communicating paths by which debris generated by a major pipe break could reach the emergency recirculation sump.
3. Details of the insulation that could be dislodged and become a source of debris as a result of a major break.

Reflective metallic insulation, manufactured and installed as shown on the drawings contained herein, is used for the majority of equipment and piping inside the containment. Antisweat insulation is used for the low pressure service water lines and some component cooling water lines. Heat traced thermal insulation is used for the nitrogen lines inside the containment.

B. LISTING OF INPUT DRAWINGS AND OTHER DOCUMENTS

This section provides a listing of drawings showing details of the containment and reactor building, emergency sump details, flow diagrams for insulated systems inside containment, and piping layout drawings (marked to show location of insulation). Also included is an Oconee Piping Insulation Standard (2C1).

Sufficient information is included herein for an organization to conduct an independent debris analysis.

1. Documentation

    - Oconee Piping Insulation Standard 2C1

2. Drawings

    a. General Arrangements-Containment and Reactor Building

    Refer to Oconee FSAR

    b. Structural Drawings

0-1067A	Reactor Building Units 2 and 3 Plan at El 777'+6" (1) Basement Floor Slab Concrete

0-1067D	Reactor Building Units 2 and 3 Floor Plan at El 797'+6" Concrete Slabs and Beams Reinforcing
0-1067J	Reactor Building Units 2 and 3 Floor Slab at El 861'+6" Concrete and Reinforcing
0-1069A	Reactor Building Units 2 and 3 Primary and Secondary Shield Walls Plans at El 777'+6" and 802'+0" Concrete
0-1069B	Reactor Building Units 2 and 3 Primary and Secondary Shield Walls Plans at El 816'+6" and 844'+6" Concrete
0-1069C	Reactor Building Units 2 and 3 Secondary Shield Walls Plan at El 861'+6" and El 857'+0" Concrete
0-1069D	Reactor Building Units 2 and 3 Primary and Secondary Shield Walls Sections and Elevations Concrete
0-1069N	Reactor Building Units 2 and 3 Secondary Shield Walls Elevations and Sections Concrete
0-1069Z	Reactor Building Units 2 and 3 Secondary Shield Walls Plans at El 828'+5" and El 835'+0" Concrete
0-1070K	Reactor Building Units 2 and 3 Primary and Secondary Shield Walls Sections and Elevations Concrete

(1) In all drawings listed herein, Elxxx'+x" is used interchangeably with standard notation Elxxx'-x".

c. Emergency Sump Design Details

0-1067A	These details are found on this drawing listed in 2.b.

d. Flow Diagrams for Insulated Systems Inside Containment

PO-100A-3	Reactor Coolant System (RC)
PO-101B-3	High Pressure Injection System (HP)
PO-102A-3	Low Pressure Injection and Core Flooding System (LP)
PO-107A-3	Coolant Storage System (Quench Tank Portion)
PO-110A-3	Chemical Addition and Sampling System
PO-121B-3B	Feedwater System (FWD)
PO-122A-3	Main Steam and Auxiliary Steam System (MS)
PO-124C	Service Water System Auxiliary and Reactor Buildings

e. Piping Layout Drawings (Reactor Building Unit 3) (Marked to Show Thermal Insulation)

0-2478A	Basement Floor Plan
0-2478B	Basement Floor Sections
0-2478C	Basement Partial Plans
0-2478D	Basement Floor Partial Plan and Section
0-2478E	Basement Floor Partial Plan and Sections OTSG Recirculation System
0-2479A	Ground Floor Plan
0-2479B	Ground Floor Sections
0-2479C	Ground Floor Sections
0-2479D	Ground Floor Partial Plans
0-2479E	Ground Floor East Partial Plan and Section

0-2479F	Ground Floor West Partial Plan and Section
0-2479G	Ground Floor East Partial Plan and Section
0-2479H	Ground Floor West Partial Plan and Section
0-2480A	Intermediate Floor Plan
0-2480B	Intermediate Floor Sections and Partial Plan
0-2480C	Intermediate Floor Sections
0-2480D	Sections and Details Intermediate Floor
0-2481A	Operating Floor Plan
0-2481B	Operating Floor, Partial Plan and Sections
0-2481C	Operating Floor Sections

f. Reflective Metallic Insulation Drawings

Equipment	Insulation Thickness	Drawing Number
Reactor Vessel	-	See FSAR for details.
Steam Generator	Varies-See dwg.	500627-028C Sh 1 and 2 500627-032C 500627-029C Sh 1 and 2 500627-030C Sh 1 and 2
Pressurizer	4"	500627-136C 500627-137C 500627-140C 500627-138C
Coolant Pumps	Varies-See dwg.	500627-363C 500627-364C 500627-365C

Piping System	Pipeline	Insulation Thickness	Drawing Number
Reactor Coolant	28" Inlet Piping from Steam Generator to Coolant Pump	Varies- See dwg.	500627-557C 500627-558C 500627-559C Sh 1 and 2
	36" Coolant Outlet from Steam Generator	"	500627-390C 500627-391C
	10" Pressurizer Surge Line	"	500627-388C
Main Steam	26" and 36" Main Steam Piping	"	500627-393C 500627-394C
Main Feedwater	24" and 14" Feedwater Piping	"	500627-612C 500627-613C
Auxiliary Feedwater	6" Piping	"	500627-644C 500627-645C
High Pressure Injection	2-1/2" Piping	"	500627-611C
Decay Heat Removal	10" Piping	"	500627-392C Sh 1 to 4
Pressurizer Spray	2-1/2" Piping	"	500627-395C Sh 1 and 2
Steam Generator Flush Piping	4" and 1" Piping	"	500627-978C Sh 1 to 5
Nitrogen	1" Piping		500627-857C Sh 1 to 6

g. Platform Drawings Inside Containment

0-0165A	Floor Plan at El 797'+6" Concrete and Structural Steel
0-0165B	Platform Plans, Typ Stair Elev Crane Catwalk, Crane Girder Structural Steel
0-0165C	Floor Plan at El 825'+0" Structural Steel

0-0165D	Floor Plan at El 844'+6" Framing Section Concrete and Structural Steel
0-0165E	Floor Plan at El 861'+6" Elevator and Stair Framing Concrete and Structural Steel
0-0165N	Platforms Around Steam Generators Structural Steel
0-0165P	Platforms Around Steam Generators Structural Steel
0-0165Q	Lower Platforms Around Steam Generators Structural Steel
0-0165R	Platforms Around Steam Generators Details Structural Steel
0-0165T	Steam Line Supports
0-0165U	Platform at 817'+0" and Elevator Mach Room Stairs Structural Steel
0-1019	RCP Access Platforms El 836'+3-3/4" Plans Sections and Details
0-1094	Misc Access Platforms Plans Sections and Details
0-1095	Misc Access Platforms Plans Sections and Details
0-1096	Misc Access Platforms Plans Sections and Details
0-1097	Misc Access Platforms Plans Sections and Details
0-1098	Misc Access Platforms Plans Sections and Details
0-1099A	Misc Access Platforms Plans Sections and Details
0-1099B	Misc Access Platforms Plans Sections and Details

C. LISTING OF PIPING SYSTEMS INSIDE CONTAINMENT CONTAINING INSULATION

This section provides a list of the systems inside the containment containing insulation. The list includes the system, nominal pipe sizes inside containment, and the type of insulation used for each system.

System	Nominal Pipe Sizes (Inches)	Type of Insulation
Reactor coolant	36, 28, 10	Reflective metallic
Main steam	36, 26	Reflective metallic
Main feedwater	24, 14	Reflective metallic
Auxiliary feedwater	6	Reflective metallic
High pressure injection	2-1/2, 4	Reflective metallic
Decay heat removal	10	Reflective metallic
Pressurizer spray	2-1/2	Reflective metallic
Steam generator blowdown piping	4, 1	Reflective metallic
High temperature sample line	1	Reflective metallic
Core flooding	14	Reflective metallic
Letdown piping	10	Reflective metallic
Low pressure Service water	10, 8, 6, 4 3	Antisweat fiberglass with metal lagging
Component cooling lines (to control rod drive service structure)	3	Antisweat fiberglass with metal lagging
Nitrogen	1	Heat traced Armstrong Armaflex outside shield wall Heat traced mirror insulation inside shield wall

D. TYPICAL INSULATION DETAILS

Reflective metallic insulation is used for all piping and equipment inside the reactor containment building with the exception of the low-pressure service water piping, component cooling-water piping, and nitrogen piping. The insulation used for the low-pressure service water piping and component cooling-water is 1 inch fiberglass with metal jacketing. The insulation used for the nitrogen piping outside the shield wall is Armstrong Armaflex, which is elastomeric with a closed-cell structure with low water vapor permeance and a density of 5.4 lbs/ft^3. The insulation contractor is Mirror Insulation, a unit of Diamond Power Specialty Company.

The conclusions of the Diamond Power Specialty Company report entitled "Response of Mirror Insulation to LOCA conditions"[1] are applicable to the reflective insulation installed in this facility.

E. PIPE BREAK LOCATIONS

Not developed for Oconee Unit 3.

F. FSAR REFERENCES ON PERTINENT INSULATION QUESTIONS

None were submitted by Duke Power Company.

G. PRELIMINARY INSULATION DEBRIS HAZARD ANALYSIS

Figure D-1 is a simplified sketch of Oconee Unit 3 reactor containment. The reactor vessel, steam generators, primary coolant pumps, pressurizer, and emergency sump are all located within the shield wall. Figure D-2 shows the location of the emergency sump in the basement of the reactor containment at El. 777'+6". Large openings in the shield wall are provided at that level to allow drainage of water during an accident across the basement floor to the emergency sump. Figure D-3 shows the details of the emergency sump.

Insulation debris resulting from a break in piping in the general area of the sump could land on the grating of the emergency sump and cause some blockage.

All of the piping inside the shield wall is insulated with reflective metallic insulation with the exception of the low pressure service water piping for the reactor coolant pump motors, which is covered with antisweat insulation.

Platform gratings would catch some of this antisweat insulation. A substantial quantity of fiberglass antisweat insulation could fall to the base ment floor during a high-energy pipe break and float towards the emergency sump.

Component cooling water piping to the control rod drives are antisweat insulated to prevent sweat from dripping on the cables. If the insulation becomes dislodged, it would land in the fuel transfer canal and not find its way to the emergency sump.

The nitrogen piping located outside the shield wall is composed of 1-in. pipes, heat-traced and insulated with Armstrong Armaflex. The low-pressure service water system piping is the only insulated piping outside the shield wall area that could contribute a significant amount of debris during a pipe break. Most of this piping is not located near high energy piping.

H. REFERENCE

1. Diamond Power Specialty Company, "Response of Mirror Insulation to LOCA Conditions," Diamond Power Specialty Company Report, May 30, 1978.

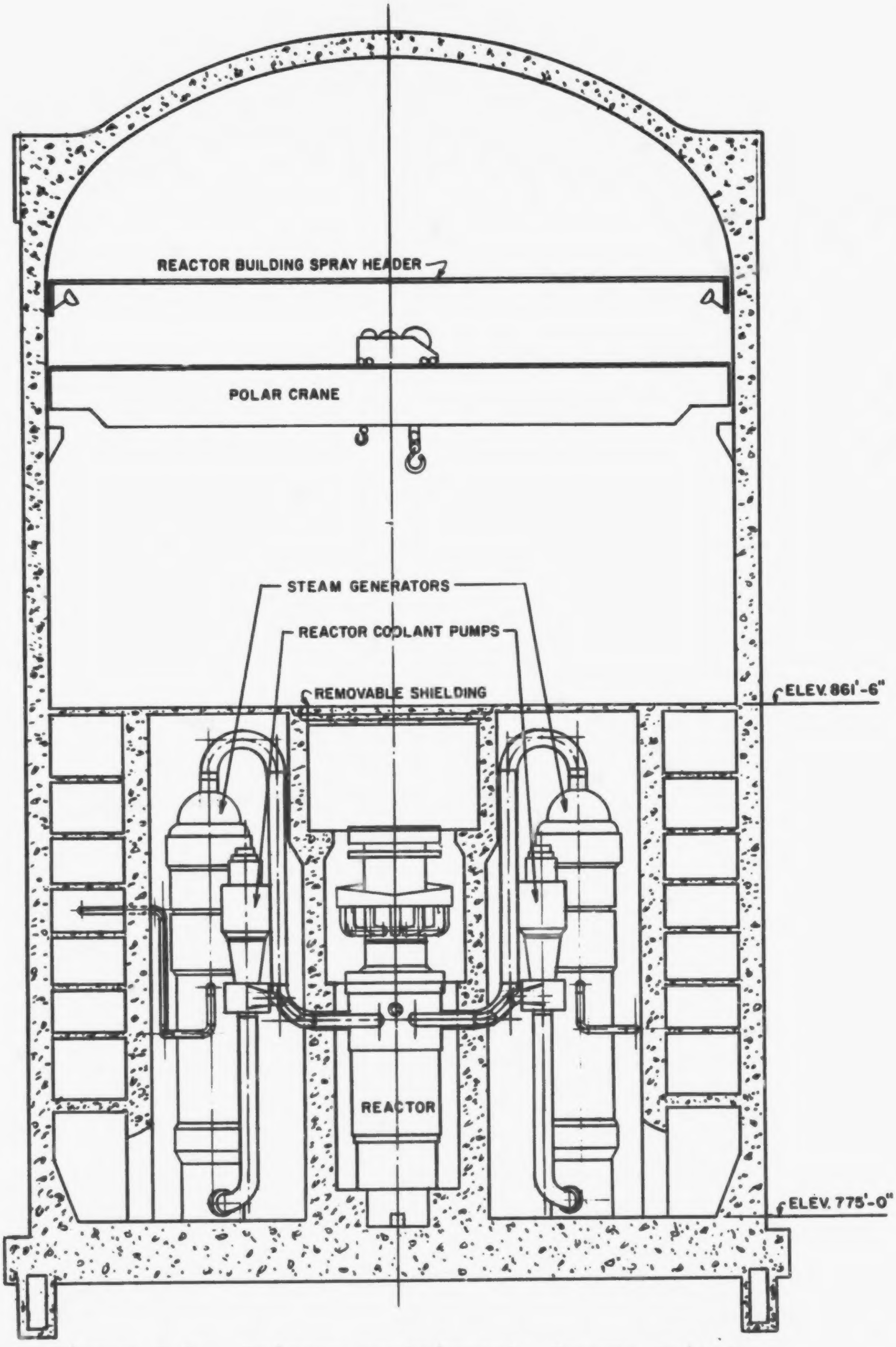
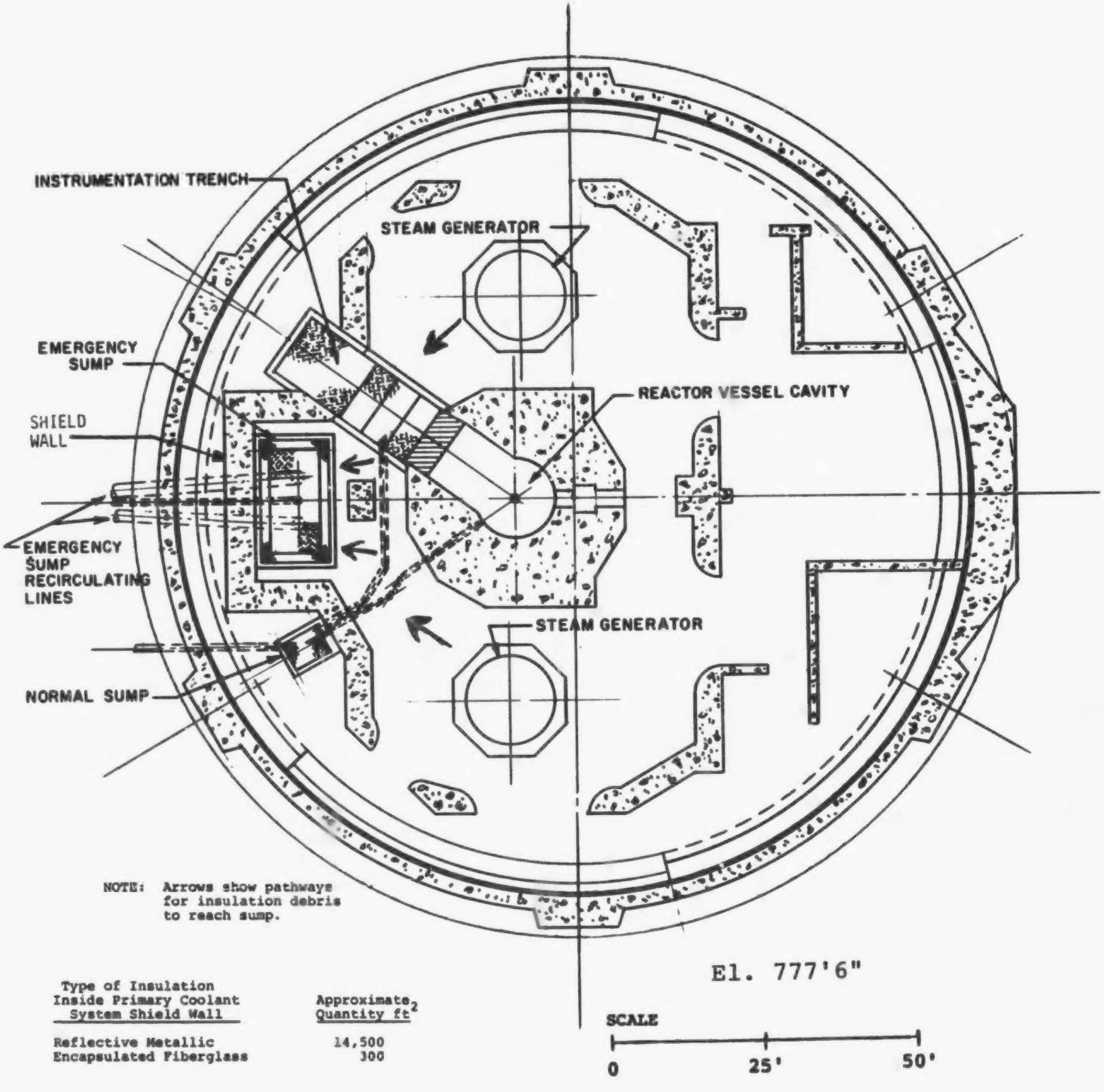

REACTOR BUILDING SPRAY HEADER
POLAR CRANE
STEAM GENERATORS
REACTOR COOLANT PUMPS
REMOVABLE SHIELDING
ELEV. 861'-6"
REACTOR
ELEV. 775'-0"

Figure D-1. Primary containment, Oconee Unit 3

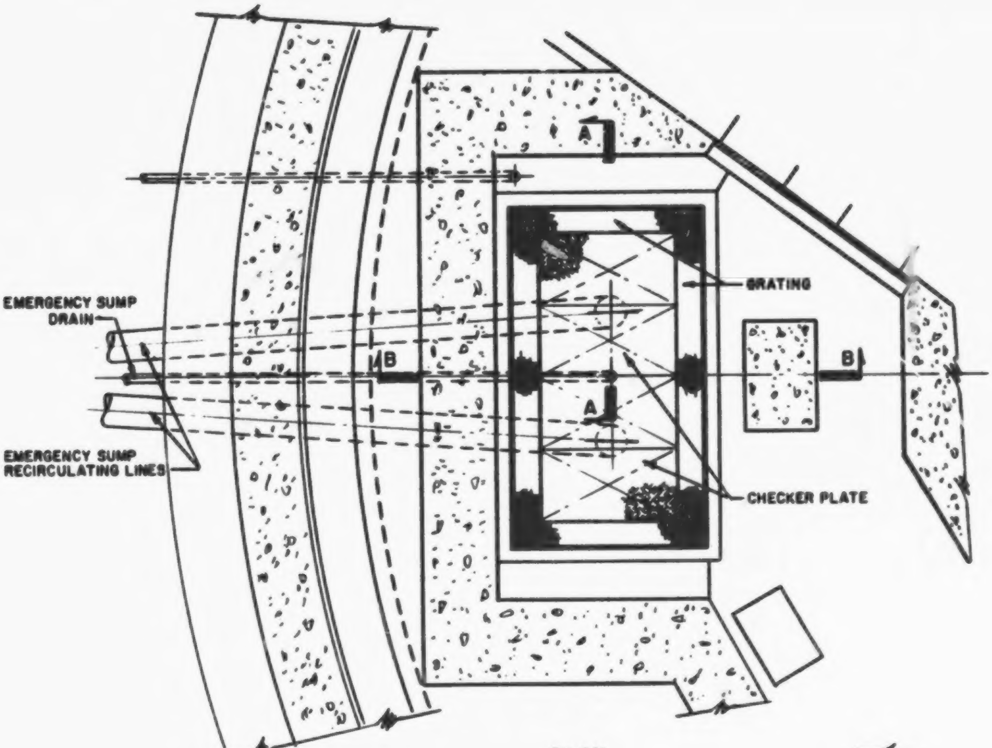


INSTRUMENTATION TRENCH
STEAM GENERATOR
EMERGENCY SUMP
REACTOR VESSEL CAVITY
SHIELD WALL
EMERGENCY SUMP RECIRCULATING LINES
STEAM GENERATOR
NORMAL SUMP
El. 777'6"
SCALE
0
25'
50'

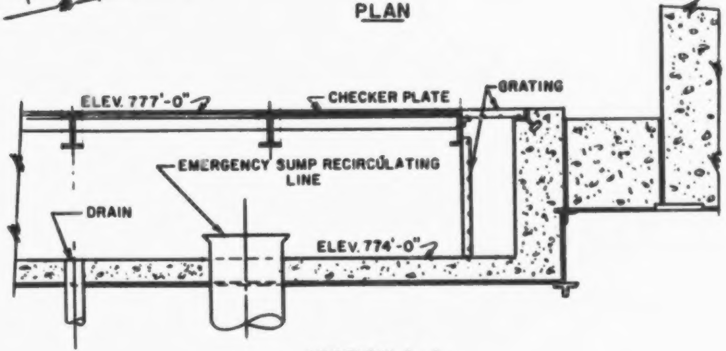
NOTE: Arrows show pathways for insulation debris to reach sump.

Type of Insulation Inside Primary Coolant System Shield Wall	Approximate Quantity ft^2
Reflective Metallic	14,500
Encapsulated Fiberglass	300

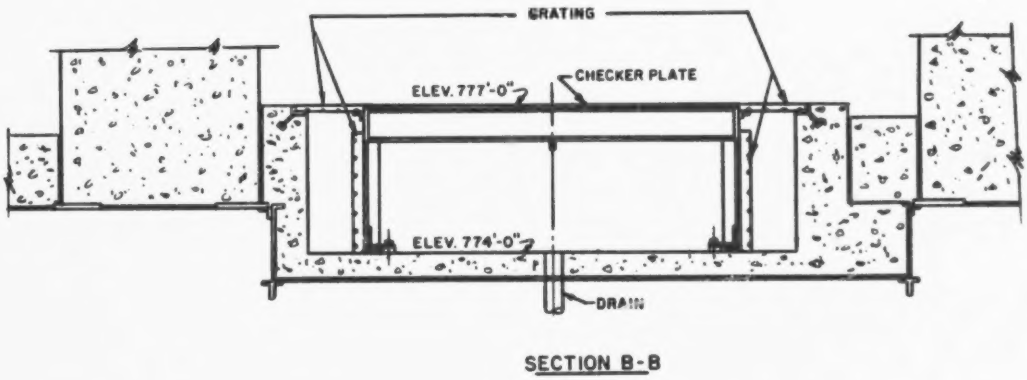
Figure D-2. Reactor building plan, Oconee Unit 3


EMERGENCY SUMP DRAIN
EMERGENCY SUMP RECIRCULATING LINES
GRATING
CHECKER PLATE
A
A
B
B

PLAN


ELEV. 777'-0"
CHECKER PLATE
GRATING
EMERGENCY SUMP RECIRCULATING LINE
DRAIN
ELEV. 774'-0"

SECTION A-A


GRATING
ELEV. 777'-0"
CHECKER PLATE
ELEV. 774'-0"
DRAIN

SECTION B-B

Figure D-3. Emergency sump, Oconee Unit 3

APPENDIX E

MIDLAND UNIT 2:

PRELIMINARY ASSESSMENT OF INSULATION DEBRIS GENERATED DURING A PIPE BREAK EVENT

A. INTRODUCTION

This report documents the information sent to Burns and Roe, Inc., by Consumers Power Company for the survey of thermal insulation used inside the reactor containment of the 805 MWe, Babcock & Wilcox PWR, Midland Unit 2, scheduled for commercial operation in 1983.

The information gathered depicts the following:

1. The arrangement of all piping within the primary containment including high energy fluid piping
2. The location and configuration of the emergency intake for emergency core cooling, and the communicating paths by which debris generated by a major pipe break could reach the emergency recirculation sump
3. Details of the insulation that could be dislodged and become a source of debris as the result of a major break

Stainless steel, metallic reflective insulation manufactured by Mirror Insulation, a unit of Diamond Power Specialty Company, is used for the reactor coolant piping system, reactor vessel, and the steam generators.

Stainless steel encapsulated mineral wool or fiberglass insulation for removable assemblies is used for the pressurizer, reactor coolant pumps, and secondary system piping (including main steam and feedwater) components.

B. LISTING OF INPUT DRAWINGS AND OTHER DOCUMENTS

This section provides a listing of documents and drawings showing details of the reactor building containment's emergency sump and drawings of piping layout. Also included is the relevant FSAR section describing the insulation inside containment.

Not included are structural steel platforms and drawings of insulation.

1. Documentation

    a. Midland 1 & 2 FSAR, Section 6.2.2.1.2.4 Insulation (Page 6.2-74, Rev. 15, 11/78), with tables 6.2.-33 and 6.2.-34 (Rev. 8, 4/78)

    b. Report No. 73024 "Model Testing of Containment Sump ECCS Recirculation Intakes" by Western Canada Hydraulic Laboratories Ltd., dated April 1980

2. Drawings

   a. Architectural Cuts (none have drawing numbers)

      Elevation of Unit 2 Containment

      Plan View of Containment at Elevation 584'-0"

      Plan View of Containment at Elevation 614'-0" and 626'-0"

      Plan View of Containment at Elevation 634'-6" and 640'-0"

      Plan View of Containment at Elevation 659'-0"

      Plan View of Containment at Elevation 685'-0"

   b. Piping Drawings (Reactor Building, Unit 2)

      M-74(Q), Plan of El. 593'-6" (Rev. 5)

      M-75(Q), Plan of El. 626'-0" (Rev. 4)

      M-76(Q), Plan of El. 640'-0" (Rev. 4)

      M-77(Q), Plan of El. 659'-0" (Rev. 5)

      M-78(Q), Miscellaneous Plans & Sections (Rev. 1)

      136062E Arrgt. of R.C. System, Elevation

      136298 Arrgt. of R.C. System, Plan

   c. Piping Isometrics (Inside Containment)

      M-638 Sht 13(Q) Feedwater and Condensate Systems (Unit 2)

      M-601 Sht 1(Q) Reactor Coolant and Pressure Control System (Rev. 9)

      M-631 Sht 1 (Q) Main Steam and Turbine Steam System Unit 1 (Rev. 3)

   d. Reactor Building Sump Details

      C-495(Q) Reactor Sump Plans and Sections (Rev. 6)

   e. Insulation Drawings

      None Provided

C. LISTING OF PIPING SYSTEMS INSIDE CONTAINMENT CONTAINING INSULATION

This section provides a list of the piping systems inside the reactor containment fitted with insulation. The list includes the system, nominal pipe sizes inside the containment, and the type of insulation used for each system.

System	Nominal Pipe Sizes (Inches)	Type of Insulation
Reactor coolant system	36, 28	Reflective metallic
Pressurizer surge line	10	Reflective metallic
Pressurizer spray line	2-1/2	Encapsulated
Decay heat removal	12	Encapsulated
High-pressure injection	2-1/2	Encapsulated
Miscellaneous piping	4, 3, 1-1/2, 1	Encapsulated
Primary system valves	1 through 12	Encapsulated
Pipe whip restraints		Reflective metallic and encapsulated
Secondary system piping	6 through 36	
	2 and Smaller	Encapsulated
Secondary system valves	6 through 18	Encapsulated
Secondary system restraints	-	Encapsulated

NOTE: Encapsulated indicates mineral wool or fiberglass fillers.

Equipment Inside Secondary Shield Wall	Type of Insulation
Reactor vessel head and flanges	Reflective metallic
Reactor vessel insulation	Reflective metallic
Reactor coolant pumps (four)	Encapsulated
Steam generators	Reflective metallic
Pressurizer	Encapsulated

NOTE: Encapsulated indicates mineral wool or fiberglass fillers.

D. TYPICAL INSULATION DETAILS

As indicated above, thermal insulation used inside the containment consists primarily of metallic reflective insulation for primary piping, steam generators, and reactor vessel and encapsulated nonmetallic insulation for pressurizer, reactor coolant pumps, and secondary system piping and components.

All insulation piping assemblies are designed to be supported separately from the associated piping. Reactor vessel, steam generator, and pressurizer insulation are supported by separate steel support structures.

All piping insulation is readily removable and is attached by means of stainless steel buckles or other fasteners of the quick release type. Equipment insulation is attached by screws where quick removability is not essential and by means of buckles or other fasteners of the quick release type which will vary depending upon installation requirements for the remaining locations.

Each insulation assembly is a rigid body jacketed in heavy gage stainless steel and designed to withstand vibration and seismic shock associated with postulated accident conditions inside containment. With the exception of local failure near postulated reactor coolant system pipe ruptures, insulation assemblies are expected to remain intact during and after a LOCA without loss of structural integrity or thermal efficiency.

Latest information from Consumers Power Company indicates that the small amounts of fiberglass insulation on the hot and cold leg pipes from the reactor vessels to the outside surface of the biological shield described in FSAR Section 6.2.2.1.2.4, Page 6.2.-74, Revision 15[1], have been eliminated. All reactor coolant piping insulation is now of the reflective metallic type.

The reflective metallic insulation used for equipment and piping inside containment is manufactured by Mirror Insulation, a unit of Diamond Power Specialty Company. The insulating material used for the reflective insulation is all-metal AISI Type 304 stainless steel.

The encapsulated mineral wool or fiberglass insulation used for equipment and piping inside containment looks similar to the removable reflective insulation. It consists of mineral wool or fiberglass block encapsulated in stainless steel removable assemblies for inservice inspection. The molded blocks are provided in thicknesses of up to 4 inches and lengths of up to 3 feet. The density of mineral wool or fiberglass block is approximately 14.0 lb/ft^3. The flexural strength is 35 psi and compressive strength is 60.0 psi.

Piping sections and equipment not required to be removable for inservice inspection are covered with formed mineral wool or fiberglass block insulation jacketed with 0.010 inch thick stainless steel inside containment and aluminum for the portion outside.

E. PIPE BREAK LOCATIONS

Refer to the FSAR for a list of the pipe break locations for high energy piping inside the reactor containment.

F. FSAR REFERENCES ON PERTINENT INSULATION QUESTIONS

None were submitted by Consumers Power Company.

G. PRELIMINARY INSULATION DEBRIS HAZARD ANALYSIS

Figure E-1 is a simplified sketch of Midland Unit 2 reactor containment. The reactor vessel, steam generators, pressurizer, and associated piping are all located inside the secondary shield wall. The emergency sump is located outside the secondary shield wall on the basement floor at Elev. 593'6". Figure E-2 shows the details of the emergency intake sump.

Each unit of the Midland plant contains a single containment sump well located on the east side of the containment building in Unit 1 and on the west side of the containment building in Unit 2 (Figure E-2). The sump well configuration of Unit 2 is a mirror image of that of Unit 1. Each sump well is divided into two independent sumps by a sump divider wall that extends from the sump floor to the trash rack cover. The dimensions of the independent sumps are 9.91 ft by 6.49 ft in cross section and 5.83 ft in depth.

A single 24 in. intake supplying suction for both the low-pressure safety injection (LPSI) and the containment spray is housed in each sump (Figure E-3). The suction pipe from the south sump of Unit 1 has a straight run from the sump to the containment wall, and the suction pipe from the north sump of Unit 1 contains a 22° miter bend in the same pipe reach.

Debris is prevented from entering the intakes by a trash rack mounted above the sumps. The top of the trash rack, at El 597'3", is covered by 1/4 in.-thick steel plate. The trash rack grating is 2-1/4 in. by 3/16 in. flat bars on 1-3/16 in. centers. A coarse screen with a 3/8 in. square open area formed from 0.12 in. wire and a fine 16-mesh screen formed from 0.023-in. wire are separately supported by the grating using strap bars. The total open area per sump is 90.89 sq. ft.

A grating cage of 1-1/4 by 3/16 in. flat bars on 1-3/16 in. centers will be placed over each intake as a means of preventing vortices formation.

Insulation debris resulting from a pipe break within the secondary shield wall has five routes to migrate to the emergency sump as shown in Figure E-2, which shows the reactor building floor plan at elevation 593'-6".

On the basement floor (Elevation 593'-6"), insulation debris would have to float through the five openings in the shield wall and find its way to the emergency sump around building obstacles in its path. The shortest route for insulation debris to exit the secondary shield wall would be through the opening in the wall immediately adjacent to the sump. The plant drawings show a form of barrier across this opening that will prevent the flow of large pieces of insulation debris to the trash rack. Floor drains at various elevations in the reactor containment are connected by 4 in. piping to the emergency sump. These floor drains are covered with grating so that only small particles would be able to reach the emergency sumps.

Two types of insulation are located inside the secondary shield wall: reflective metallic, and encapsulated molded mineral wool or fiberglass with stainless steel jacketing. The reflective metallic insulation will sink to the floor of the containment if blown off the piping. The encapsulated mineral wool or fiberglass could float and/or sink if the insulation cavity filled with water. The molded mineral wool or fiberglass insulation with metal jacketing could separate if blown off the piping and/or equipment, and pieces could float and migrate through the openings in the shield wall to the emergency sump. The reactor coolant pumps main steam piping and the pressurizer have the largest pieces of insulation of this type.

Outside the shield wall, there is no insulation in the vicinity of the emergency sump.

H. REFERENCES

1. Midland 2, Final Safety Analysis Report, Consumers Power Company, Jackson, Michigan.

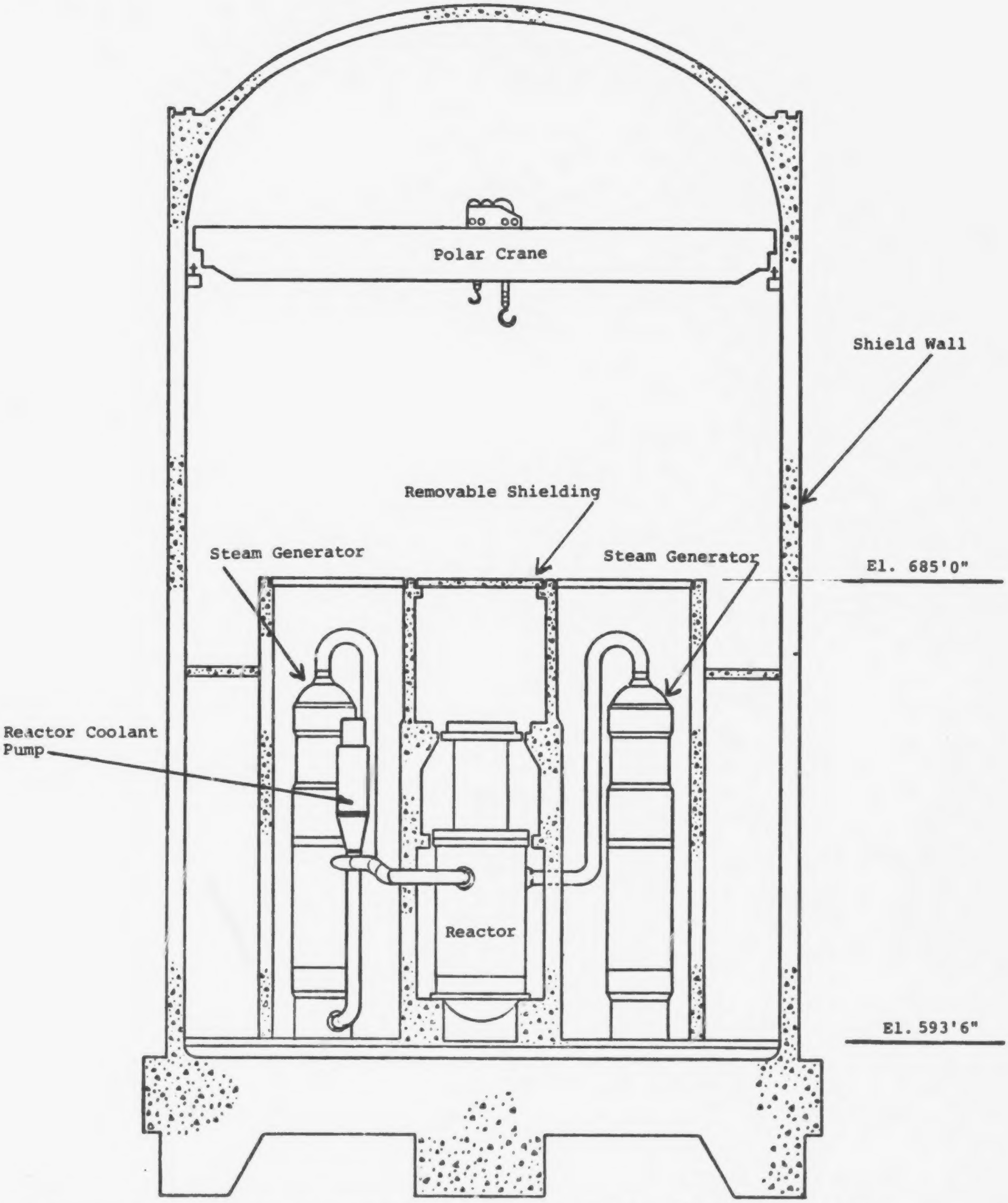
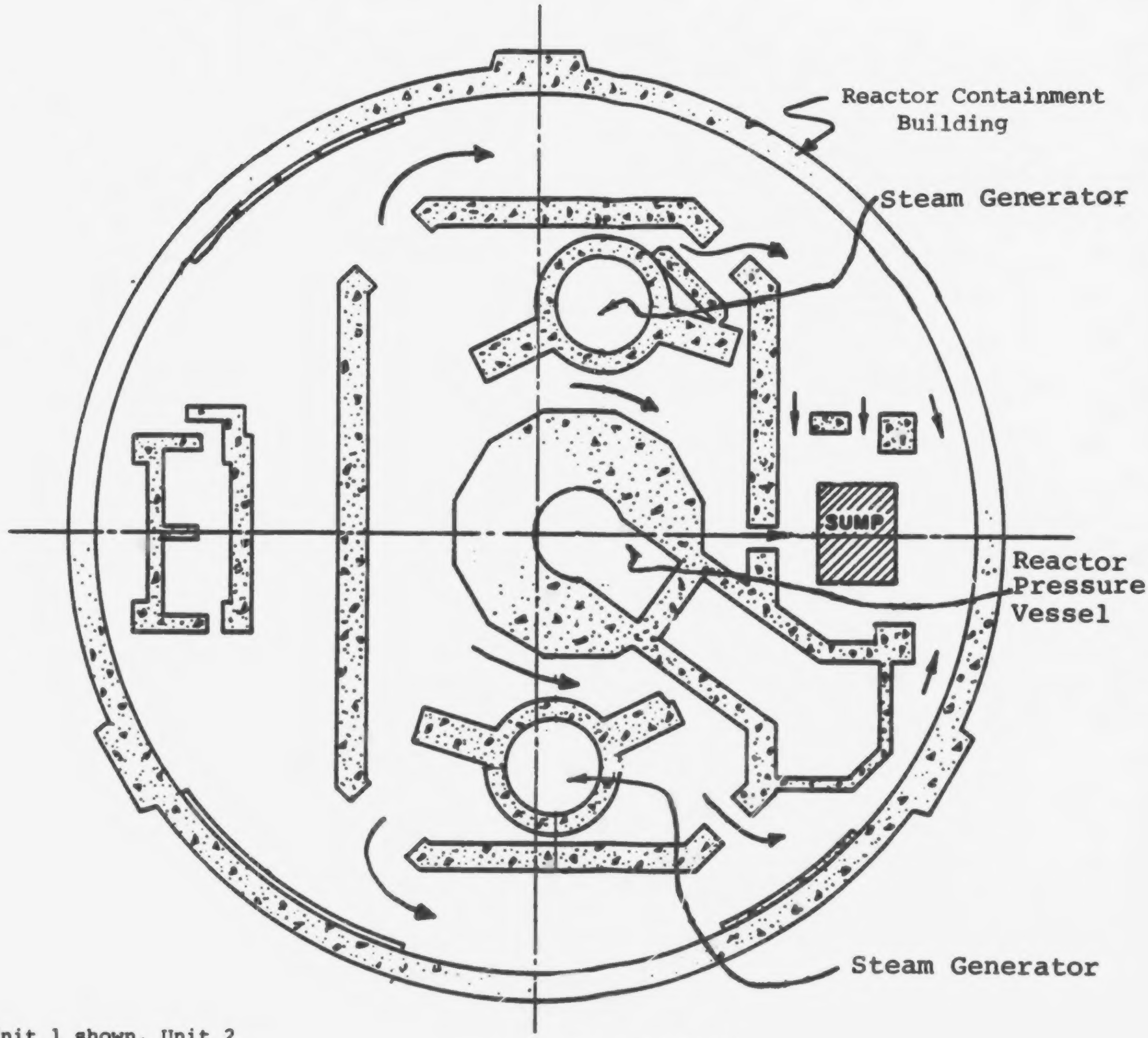

Polar Crane
Shield Wall
Removable Shielding
Steam Generator
Steam Generator
El. 685'0"
Reactor Coolant Pump
Reactor
El. 593'6"

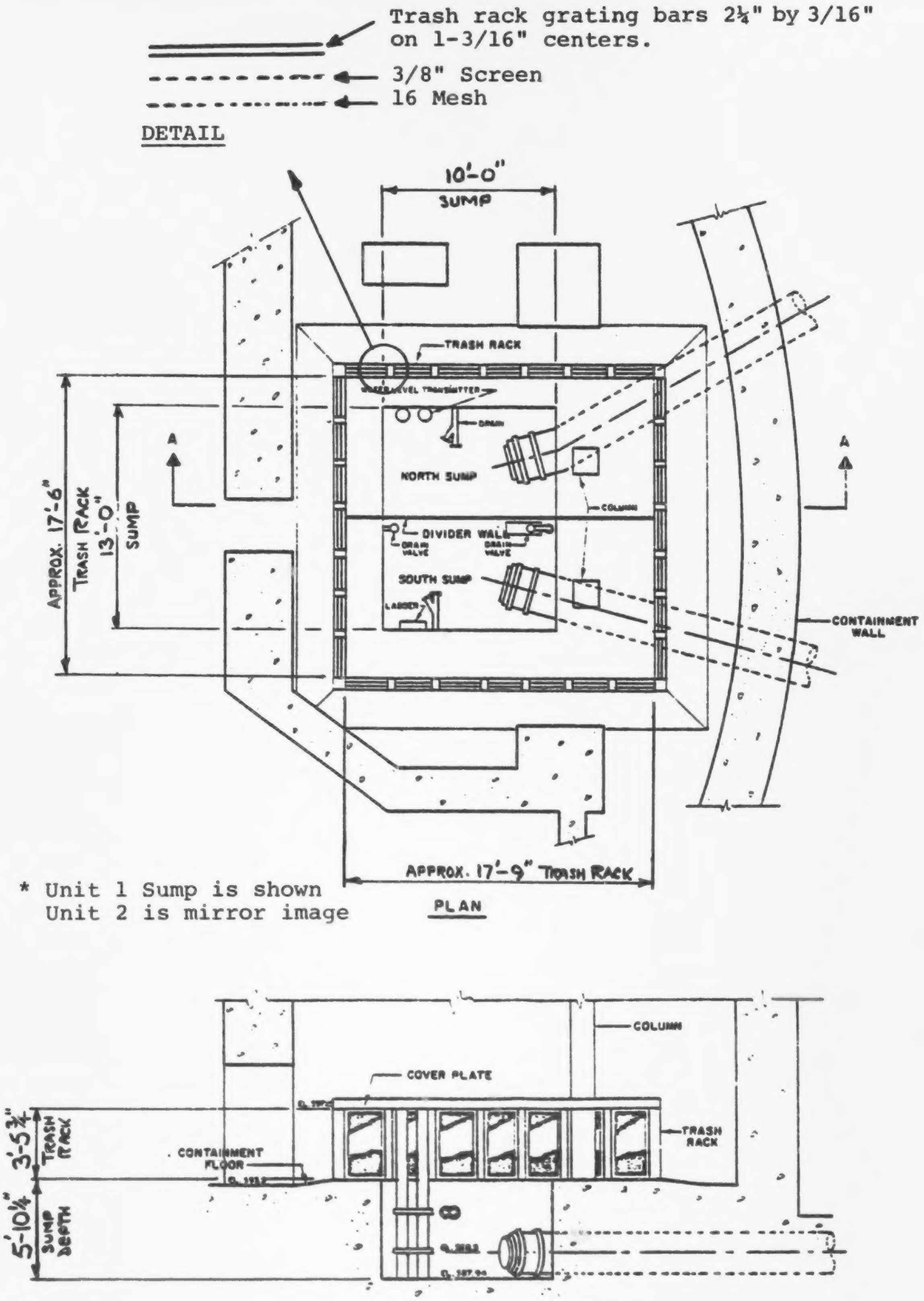
Figure E-1. Reactor containment arrangement, Midland Unit 2


Reactor Containment Building
Steam Generator
SUMP
Reactor Pressure Vessel
Steam Generator
El. 593'6"

NOTE: *Unit 1 shown, Unit 2 is mirror image. Arrows show pathways for insulation debris to reach sump.

TYPE OF INSULATION INSIDE SECONDARY SHIELD WALL	APPROXIMATE QUANTITY FT^2
Reflective Insulation	15,750
Encapsulated Mineral Wool or Fiberglass	4,400

Figure E-2. Primary containment, Midland Unit 2*


Trash rack grating bars 2¼" by 3/16" on 1-3/16" centers.
3/8" Screen
16 Mesh
DETAIL
10'-0"
SUMP
TRASH RACK
WATER LEVEL TRANSMITTER
DRAIN
A
NORTH SUMP
COLUMN
DIVIDER WALL
DRAIN VALVE
DRAIN VALVE
SOUTH SUMP
LADDER
A
APPROX. 17'-6" TRASH RACK
13'-0" SUMP
CONTAINMENT WALL
APPROX. 17'-9" TRASH RACK
PLAN
COLUMN
COVER PLATE
TRASH RACK
CONTAINMENT FLOOR
3'-5¾" TRASH RACK
5'-10¼" SUMP DEPTH
EL. 187.94

* Unit 1 Sump is shown
Unit 2 is mirror image

Figure E-3. Detailed drawing of sump, Midland Unit 2*

APPENDIX F

MAINE YANKEE:

PRELIMINARY ASSESSMENT OF INSULATION DEBRIS GENERATED DURING A PIPE BREAK EVENT

A. INTRODUCTION

This report documents the information gathered by Burns and Roe's survey of thermal insulation inside the primary containment of the 790 MWe Combustion Engineering, PWR, Maine Yankee Nuclear Station which started commercial operation in 1972.

The information gathered depicts the following:

1. The arrangement of all piping within the primary containment including high energy fluid piping.
2. The location and configuration of the emergency intake sump for emergency core cooling, and the communicating paths by which debris generated by a major pipe break could reach the emergency recirculating sump.
3. Details of the insulation that could be dislodged and become a source of debris as a result of a major break.

Reflective metallic insulation is used for the reactor pressure vessel. Removable blankets are utilized for primary coolant equipment and piping, non-removable sections are insulated with calcium silicate block insulation or unibestos.

B. LISTING OF INPUT DRAWINGS AND OTHER DOCUMENTS

This section provides a listing of drawings and documents showing details of containment and reactor building, piping, flow diagrams, emergency sump details and insulation details obtained from Maine Yankee.

1. Documentation
    a. Addendum No. 3 to Specification MYS-3126 Thermal Insulation for Inservice Inspection
    b. Letter from Stone and Webster to Maine Yankee dated March 26, 1970 on Containment Spray Sump Screen.
2. Drawings
    a. General Arrangement - Containment and Reactor Building

11550 FM-1A	Reactor Plant - El 46'-0"
11550 FM-1B	Reactor Plant - EL 20'-0"
11550 FM-1C	Reactor Plant - EL 2'-0", 19'-2", 32'-2"
11550 FM-1D	Reactor Plant Sections A-A & C-C
11550 FM-1E	Reactor Plant Sections B-B, D-D

b. Flow Diagrams for Systems Inside Containment

11550 FM-9A	Main Steam Piping
11550 FM-12A	Steam Generator Feedwater Piping
11550 FM-26	Steam Generator Blowdown Piping
11550 FM-30	Reactor Coolant Piping
11550 FM-31 A,B,C	Chemical and Volume Control and HP Safety Injection Piping
11550 FM-32A	Residual Heat Removal, Containment Spray and LP Safety Injection Piping
11550 FM-33 A,B	Primary Vents & Drains Piping
11550 FM-34 A,B,C	Primary Component Cooling Water Piping

c. Piping Layout Drawings for Systems Inside Containment

11550-FP-2A thru 2K	Main Steam Piping
11550-FP-3A thru 3G	Steam Generator Feedwater Piping
11550-FP-9A thru 9M	Reactor Containment Annulus Piping
11550-FP-10A thru 10F	Reactor Containment to Primary Auxiliary Building Piping
11550-FP-12A thru C	Primary Water Piping
11550-FP-13A thru C	Pressurizer Spray, Safety and Quench Tank Piping
11550-FP-14A thru K	Chemical and Volume Control Piping
11550-FP-15A thru D	Safety Injection Piping
11550-FP-16A thru D	Residual Heat Removal Piping
11550-FP-17A thru E	Containment Spray Piping
11550-FP-20A thru J	Primary Component Cooling Water Piping
11550-FP-21A thru C	Steam Generator Blowdown Piping
11550-FP-24A thru J	Primary Vent and Drain Piping

d. Reactor Building Equipment and Equipment Insulation Drawings

E-233-478	Insulation Attachments for Pressurizer
E-233-472	Pressurizer Outline
2F-1205	Reactor Coolant Pump Outline
E-233-100-3	Steam Generator Outline
E-4467-210-200	Reactor Coolant Piping Arrangement

e. Platform Drawings

11550 FM-43A thru D	Reactor Containment

C. LISTING OF PIPING INSIDE CONTAINMENT CONTAINING INSULATION

This section provides a list of the equipment and systems inside primary containment containing insulation. The list includes the equipment, the system, nominal pipe sizes inside containment and the type of insulation used for each system.

System	Nominal Pipe Size (inches)	Type of Insulation
Reactor coolant	33-1/2	Blanket type
Safety injection	14, 10, 8, 4	Blanket type
Pressurizer surge line	12	Blanket type
Main steam piping	30	Calcium silicate
Feedwater	14	Calcium silicate
RHR system	14	Calcium silicate
Chemical volume and control	10, 4, 3, 2-1/2, 2	Calcium silicate
Component cooling water	Various	Fiberglass

Reflective metallic insulation is used for the reactor vessel. The pressurizer, reactor coolant pumps and steam generators are insulated with calcium silicate block insulation for non-removable sections and blanket insulation for removable sections. The three primary coolant 40 inch O.D. loops are insulated primarily with removable blankets. For the coolant and auxiliary piping within the pressure boundary, all circumferential welds in piping 8 inches and larger and subject to inservice inspection have 24 inch wide removable blanket covers centered over the weld. The balance of the piping is covered with permanent calcium silicate molded or unibestos insulation.

For piping 2 inches to 6 inches inclusive, the removable sections are molded calcium silicate or unibestos. For coolant and auxiliary piping smaller than 2 inches, permanent calcium silicate molded block or unibestos is used.

D. TYPICAL INSULATION DETAILS

Two blanket types of insulation are used for reactor coolant system piping and equipment. Initially, minerally wool with an inner blanket jacket of asbestos cloth and an outer, fine mesh textured, glass cloth was used. The asbestos cloth blankets are currently being replaced with mineral wool blankets having an inner cover of stainless steel mesh and an outer cover of fine mesh glass.

Calcium silicate insulation used for piping inside the containment is covered with a pre-sized, fine-weave glass cloth. For insulation types, blanket-to-blanket, blanket-to-permanent calcium silicate and removable-to-permanent calcium silicate, abutting sections are covered with a cemented-on strip of fine-weave glass cloth over both circumferential and longitudinal joints. The purpose of the cemented strip is to prevent the entrance of vapor. Removable and replaceable covers for flanges, valves and unions are provided. These covers are filled with refractory fibrous soft felted blanket. Insulation used for component cooling water system piping is premolded, split section, fiberglass insulation furnished with a fire retardant vapor barrier.

Vendor drawings of piping insulation were not obtained from Maine Yankee.

E. PIPE BREAK LOCATIONS

Not applicable for this plant.

F. FSAR REFERENCES ON PERTINENT INSULATION QUESTIONS

None were submitted by Maine Yankee Atomic Power Co.

G. PRELIMINARY INSULATION DEBRIS HAZARDS ANALYSIS

Figures F-1 and F-2 are simplified sketches of the Maine Yankee reactor containment. The reactor vessel, steam generators, pressurizer, and associated piping are all located inside the shield wall. The emergency sump is located outside the shield wall below the basement floor, as shown in Figure F-2. Figure F-3 shows the details of the emergency sump screen. To prevent debris from clogging spray nozzle orifices, sump screens have been sized to pass no particles larger than 3/16 inch. The emergency sump, in plan view, is a crescent. The screen frame is anchored to the sump rim and is an "A frame" constructed of 3 inch I beams. All materials used are stainless steel. The sump screen consists of an outer bar screen and an inner screen. Water flowing to the sump would pass first through the bar screen, and then through rough screens with 3/4 inch square openings and, finally, through 4" by 4" mesh screens. A partition screen in the center of the sump divides the sump in half and has a coarse-mesh screen on either side of the center fine-mesh screen. The partition screen ensures that failure of the screens over either half would not affect the other half. Each half of the sump has been designed to continue in full-flow operation even though the screens in the other half collapse or plug. Cylindrical pump screens are bolted over each of the two suction lines in the sump bottom. These fine-mesh screens provide additional protection and constitute a fourth barrier to keep out debris. A cross-over pipe is provided outside the emergency sump and allows operation of any one containment spray pump and any one low-pressure safety injection pump from either half of the sump at a full flow of 8,700 gpm. At this flow, water velocity through the screens would be 1.3 ft/sec.

Insulation debris resulting from a pipe break within the shield wall could float through openings in the shield wall and migrate towards the emergency sump. The mineral wool blanket, and calcium silicate block insulation have densities on the order of 12 lb/ft^3 and therefore could float.

Outside the shield wall, 10 inch and 4 inch high pressure safety injection pipes are located near the emergency sump. This piping is insulated with calcium silicate insulation which could become dislodged in the event of a pipe break and fall and float towards the emergency sump.

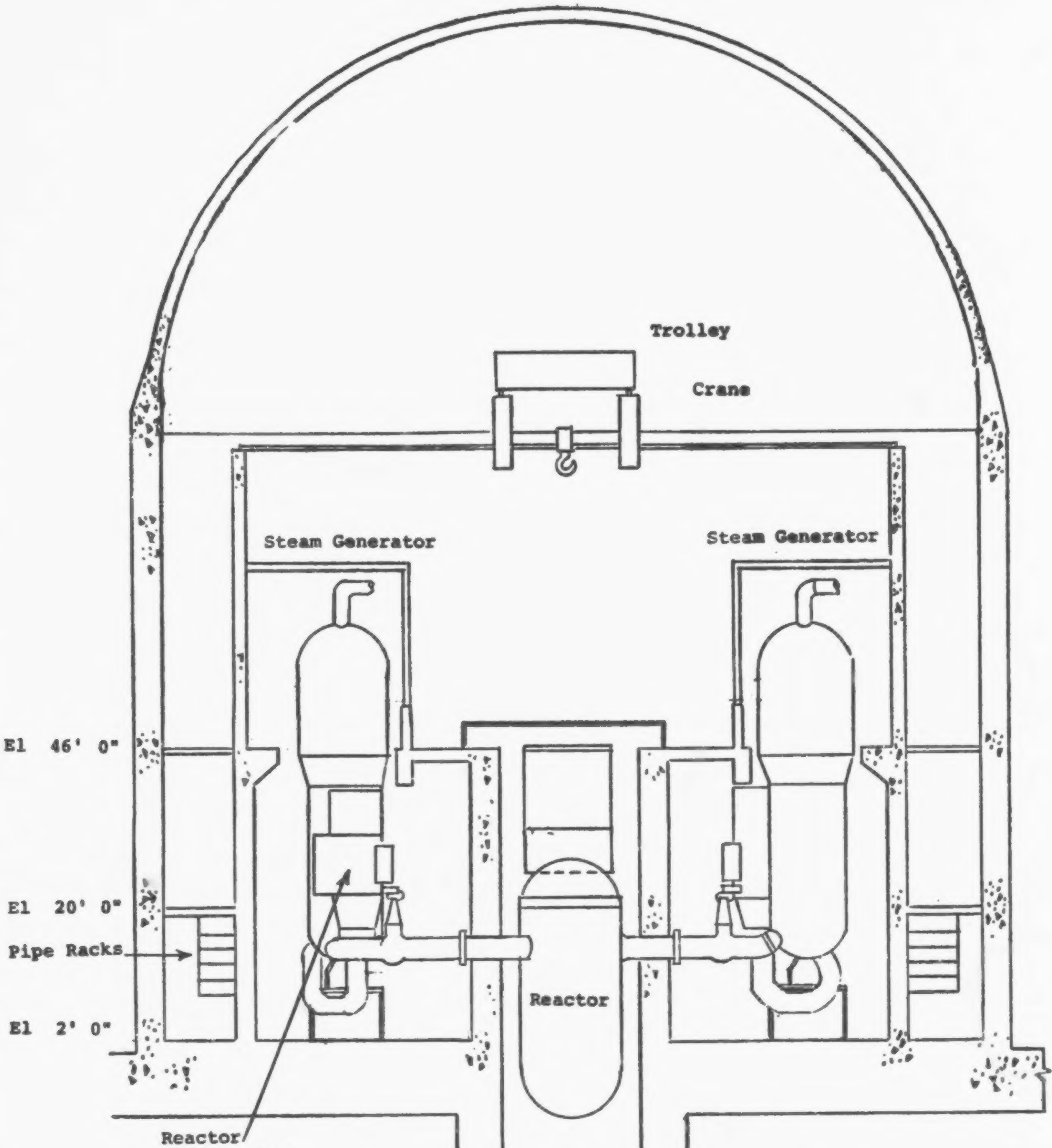
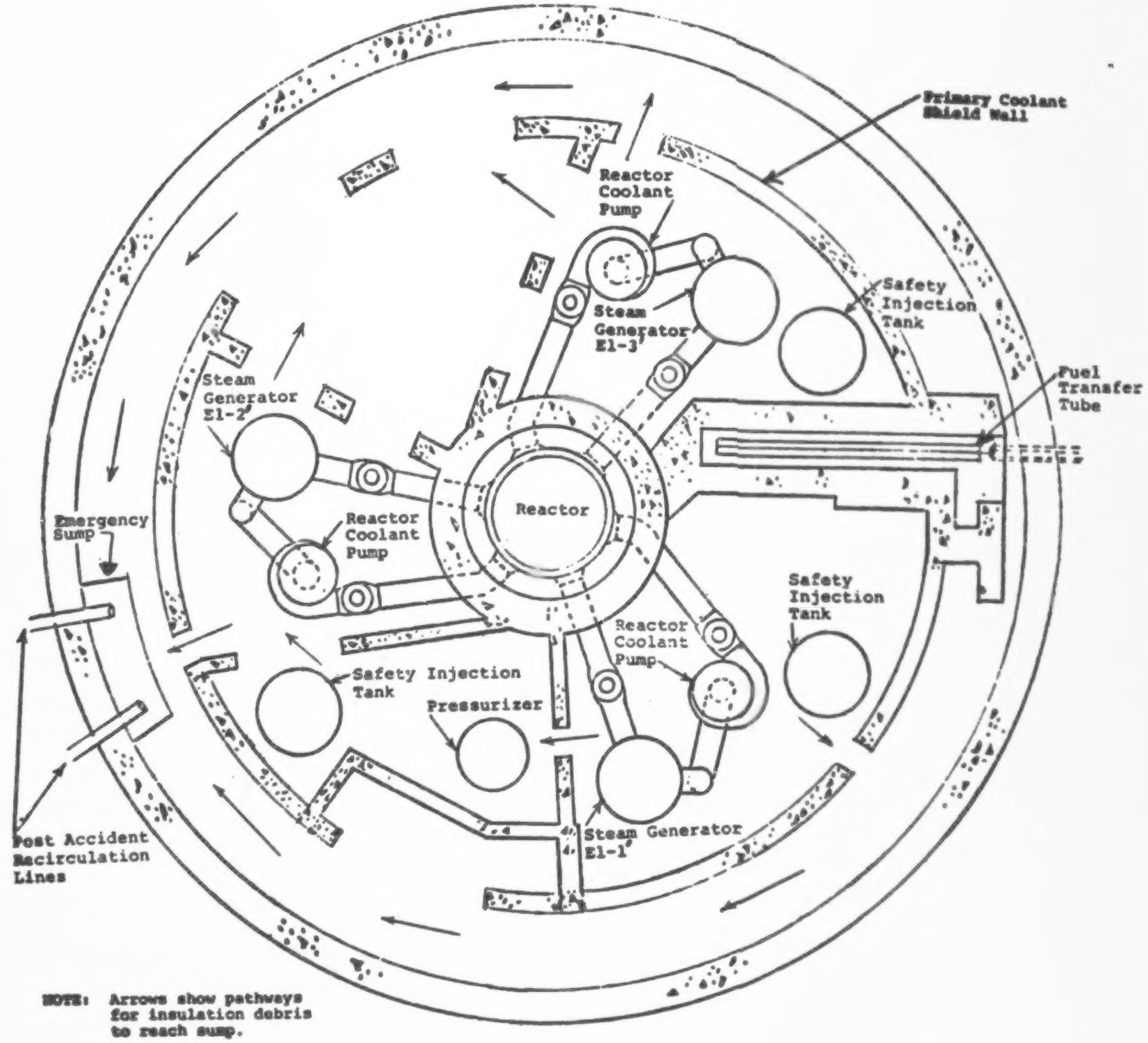

Trolley
Crane
Steam Generator
Steam Generator
El 46' 0"
El 20' 0"
Pipe Racks
El 2' 0"
Reactor
Reactor
Coolant Pump
In-Core
Instrument Pit
El -39 2"

Figure F-1. Reactor containment arrangement, Maine Yankee


Primary Coolant Shield Wall
Reactor Coolant Pump
Steam Generator El-3
Safety Injection Tank
Fuel Transfer Tube
Steam Generator El-2
Reactor
Emergency Sump
Reactor Coolant Pump
Safety Injection Tank
Reactor Coolant Pump
Safety Injection Tank
Pressurizer
Steam Generator El-1
Post Accident Recirculation Lines

NOTE: Arrows show pathways for insulation debris to reach sump.

TYPE OF INSULATION INSIDE PRIMARY COOLANT SYSTEM SHIELD WALL	APPROXIMATE QUANTITY FT^2
Reflective Metallic	1,600
Calcium Silicate/Unibestos	4,600
Mineral Wool	5,700
Fiberglass	100

El. -2' 0"

SCALE

0 25' 50'

Figure F-2. Reactor containment, Maine Yankee

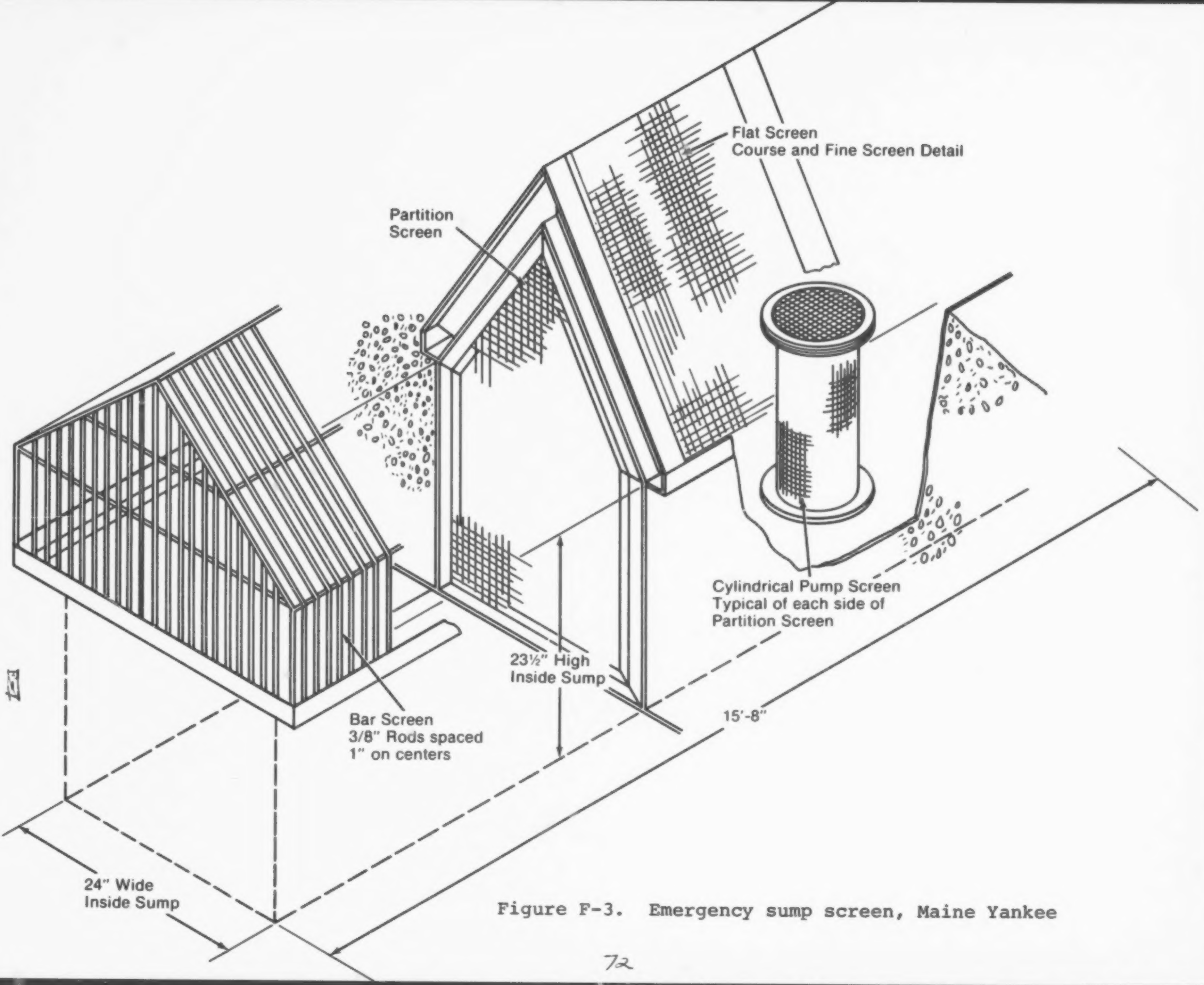

Flat Screen
Course and Fine Screen Detail
Partition
Screen
Cylindrical Pump Screen
Typical of each side of
Partition Screen
23½" High
Inside Sump
15'-8"
Bar Screen
3/8" Rods spaced
1" on centers
24" Wide
Inside Sump

Figure F-3. Emergency sump screen, Maine Yankee

APPENDIX G

ARKANSAS UNIT 2:

PRELIMINARY ASSESSMENT OF INSULATION DEBRIS GENERATED DURING A PIPE BREAK EVENT

A. INTRODUCTION

This report documents the information sent to Burns and Roe, Inc. by Arkansas Power & Light Company for the survey of thermal insulation inside the reactor containment of the 858 MWe, Combustion Engineering PWR, Arkansas Unit 2, which began commercial operation in 1980.

The information gathered includes the following:

1. The arrangement of all piping within the primary containment including high energy fluid piping
2. The location and configuration of the sump for emergency core cooling and the communicating paths by which debris generated by a major pipe break could reach the emergency recirculation sump
3. Details of the insulation that could be dislodged and become a source of debris as the result of a major break

Stainless steel, metallic reflective insulation as manufactured by Mirror is used for the reactor coolant piping system, reactor vessel, pressurizer, reactor coolant pumps, and bottom head portion of the steam generators.

Stainless steel encapsulated calcium silicate or expanded perlite removable assemblies are used for the feedwater and emergency feedwater systems, pressurizer safety relief valve, steam generator blowdown, and the steam generators inside containment. Calcium silicate or expanded perlite block with stainless steel jacketing is used for the main steam piping inside containment.

The chilled-water piping inside containment is covered with fiberglass, with stainless steel jacketing.

B. LISTING OF INPUT DRAWINGS AND OTHER DOCUMENTS

This section provides a listing of drawings showing details of the reactor building containment's emergency sump design, flow diagrams for insulated systems inside containment, and piping layout drawings. Also included is a copy of the Technical Specification for Insulation for Unit 2.

Not included are structural steel platforms and drawings of insulation.

1. Documentation

   - Specification M2136 - Technical Specification for Insulation

2. Drawings

   a. General Arrangement-Reactor Containment Building

M-2002 Equipment Location - Fuel Handling Floor
M-2003 Equipment Location - Operating Floor
M-2004 Equipment Location - Intermediate Floor
M-2005 Equipment Location - Ground Floor
M-2006 Equipment Location - Plan Below Grade
M-2007 Equipment Location - Sections "AA" and "FF"
M-2008 Equipment Location - Section "BB"
M-2009 Equipment Location - Section "CC"
M-2010 Equipment Location - Section "DD"
M-2011 Equipment Location - Mis. Plans and Section

b. Emergency Sump Design Details

C-2145 (Sh 1) Misc. Steel Plans, Details and Sections
C-2167 Reinforced Concrete Misc. Sections
M-2120 Plumbing and Drainage - Cont El 336'-6" to 357'-0"
M-2121 Plumbing and Drainage - Cont EL 376'-0" to 405'-6"

c. Flow Diagrams for Insulated Systems Inside Containment

M-2022 (Sh 1&2) P&ID Main Steam
M-2204 (Sh 4) P&ID Emergency Feedwater
M-2206 P&ID Steam Generator Secondary
M-2222 (Sh 1&2) P&ID Chilled Water System
M-2230 P&ID Reactor Coolant System
M-2231 P&ID Chemical Volume and Control System
M-2237 (Sh 1-3) P&ID Sampling System
M-2238 P&ID RCP Connections

d. Piping Layout Drawings

M2053 Cont. Area Dwg. - Plan above 426' -6:
M2054 Cont. Area Dwg. - Plan El 405'-6" to 426'-6"
M2055 Cont. Area Dwg. - Plan El 376'-6" to 405'-6"
M2056 Cont. Area Dwg. - Plan El 357'-0" to 376'-6"
M2057 Cont. Area Dwg. - Plan Below El 375'-0"
M2058 Cont. Area Dwg. - Section A25-A25
M2059 Cont. Area Dwg. - Section B25-B25
M2060 Cont. Area Dwg. - Section D25-D25, E25-E25
M2-61 Cont. Area Dwg. - Section F25-F25, G25-G25, H25-H25, J25-J25

e. Insulation Drawings

None provided.

C. LISTING OF PIPING SYSTEMS INSIDE CONTAINMENT CONTAINING INSULATION

This section provides a list of the systems inside the reactor containment containing insulation. The list includes the system, nominal pipe sizes inside containment, and the type of insulation used for each system.

System	Nominal Pipe Sizes (inches)	Type of Insulation
Safety Injection	12	Reflective metallic
Pressurizer Surge Line	12	Reflective metallic
Reactor Coolant System	42,30	Reflective metallic
Pressurizer Spray Line	3, 2	Reflective metallic
Reactor Drain Lines	2	Reflective metallic
Shutdown Cooling	14, 12	Reflective metallic
Feedwater	24	*Encapsulated calcium silicate or perlite
Emergency Feedwater	4	*Encapsulated calcium silicate or perlite
Pressurizer Safety Relief Valves to Quench Tank	10, 6	*Encapsulated calcium silicate or perlite
Main Steam	34	Calcium silicate or expanded perlite with stainless steel jacketing
Chilled Water	6, 4	Fiberglass with stainless steel jacketing

*Encapsulated insulation is used for all removable covers; calcium silicate or expanded perlite with stainless steel jacketing is used for the remainder.

Equipment Inside Primary Containment	Type of Insulation
Reactor Vessel	Reflective metallic
Reactor Coolant Pump	Reflective metallic
Pressurizer	Reflective metallic
CVCS Regen. Heat Exchanger	Reflective metallic
Steam Generator Bottom Head Up to 18" from Bottom Weld	Reflective metallic
Steam Generator - All others	Encapsulated calcium silicate or expanded perlite for removable covers. Calcium silicate or expanded perlite with stainless steel jacketing used for the remainder.

D. TYPICAL INSULATION DETAILS

The reflective metallic insulation used for equipment and piping inside containment is described in Appendix A of this report. The insulation contractor is Mirror Insulation, a unit of Diamond Power Specialty Company. The insulating material used for the reflective insulation is all metal AISI Type 304 stainless steel.

The encapsulated calcium silicate or expanded perlite insulation used for equipment and piping inside containment looks similar to the removable reflective metallic insulation. It consists of calcium silicate or expanded perlite molded block encapsulated in stainless steel removable assemblies for inservice inspection. The molded blocks are provided in thicknesses of up to 4 inches and lengths of up to 3 feet. The density of calcium silicate or expanded perlite block is approximately 14 lb/ft^3. The flexural strength is 35 psi and compressive strength is 60 psi.

Piping sections and equipment not required to be removable for inservice inspection have formed calcium silicate or expanded perlite block insulation jacketed with 0.010 inch thick stainless steel for the part inside containment and aluminum for the part outside.

E. PIPE BREAK LOCATIONS

Refer to the FSAR[1] for a list of the pipe break locations for high-energy piping inside the reactor containment.

F. FSAR REFERENCES ON PERTINENT INSULATION QUESTIONS

None were submitted by Arkansas Power & Light Company.

G. PRELIMINARY INSULATION DEBRIS HAZARD ANALYSIS

Figure G-1 is a simplified sketch of Arkansas Unit 2 reactor containment. The reactor vessel, steam generators, pressurizer, and associated piping are all located inside the shield wall. The emergency sump is located outside the shield wall on the basement floor at El. 353'-0". Figure G-2 shows the details of the emergency intake sump. The sump is divided into two parts by a 3/8 inch steel dividing wall. A separate pipe from each part goes to the emergency core cooling system. The sump is surrounded by 7'-4" high and 6'-5" wide screens to catch debris.

Two layers of screens are provided -- a coarse screen (4 mesh) and a finer screen (14 mesh). These screens are protected against damage by a 1-1/2 by 3/16 inch steel grating.

Insulation debris resulting from a pipe break within the shield wall has two routes to migrate to the emergency sumps as shown in Figure G-3.

At the basement floor El. 335'-0", insulation would have to float through the large opening in the shield wall and find its way to the emergency sump around building obstacles in its path. Floor drains at various elevations in the reactor containment are piped through 4 inch piping to the emergency sump. These floor drains are covered with grating so that only small particles would be able to reach the emergency sumps.

Three types of insulation are located inside the shield wall: reflective metallic, encapsulated molded calcium silicate or expanded perlite, and molded calcium silicate or expanded perlite with stainless steel jacketing. The reflective metallic insulation will sink to the floor of the containment if blown off the piping. The encapsulated calcium silicate or expanded perlite could float and/or sink if the insulation cavity filled with water. The molded calcium silicate or expanded perlite insulation with metal jacketing could separate if blown off the piping and/or equipment. The molded calcium silicate and/or expanded perlite pieces could float and migrate through the opening in the shield wall to the emergency sump. The main steam piping and the steam generators have the largest pieces of insulation of this type.

Outside the shield wall, no insulation is near the emergency intake sump. The stainless steel jacketed fiberglass insulation used for chilled-water piping is not located near any high-energy piping and, therefore, should not pose a problem during a pipe break event.

H. REFERENCE

1. Arkansas 2, Final Safety Analysis Report, Arkansas Power & Light Company, Little Rock, Arkansas

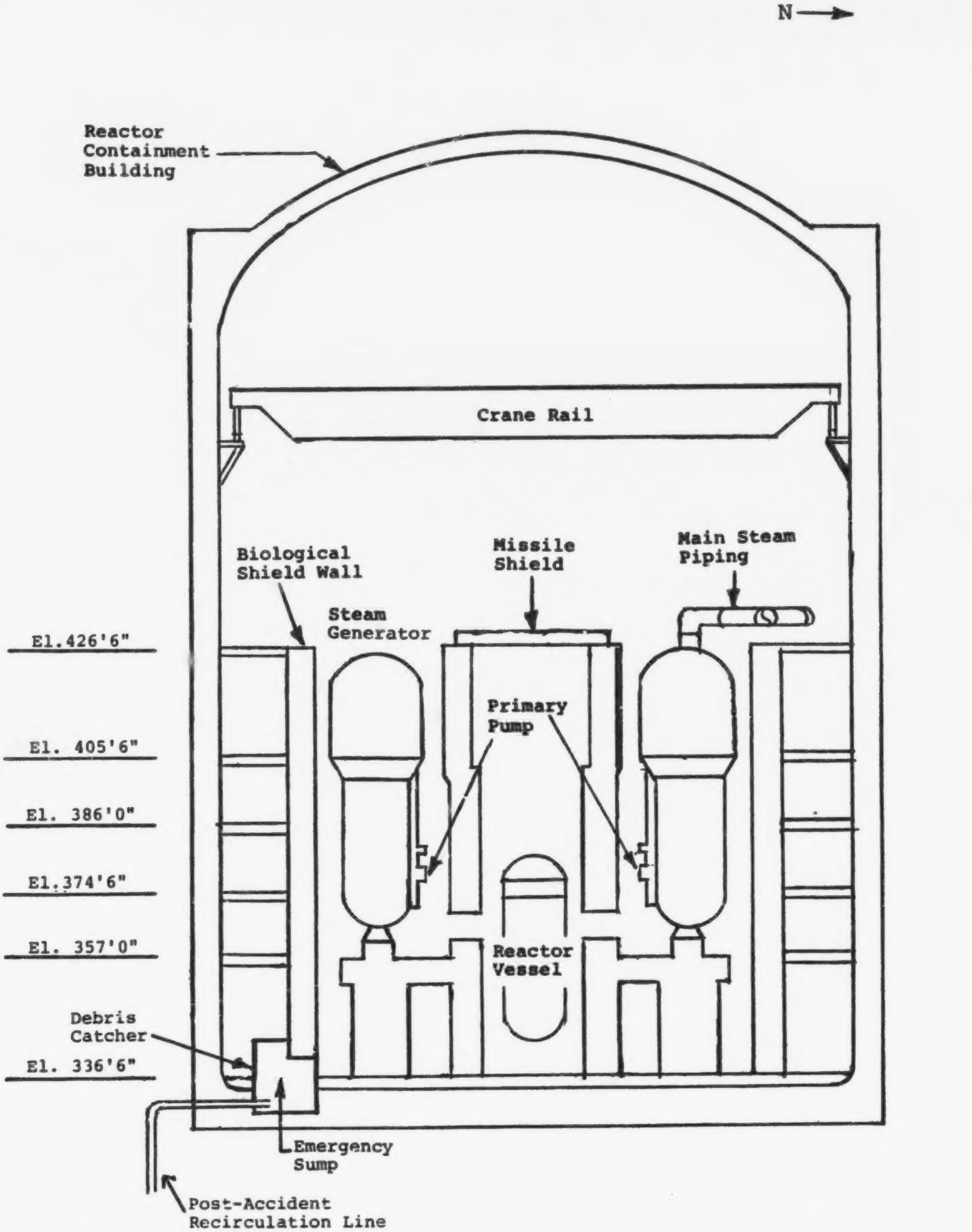

N
Reactor Containment Building
Crane Rail
Biological Shield Wall
Missile Shield
Main Steam Piping
Steam Generator
Primary Pump
Reactor Vessel
El.426'6"
El. 405'6"
El. 386'0"
El.374'6"
El. 357'0"
Debris Catcher
El. 336'6"
Emergency Sump
Post-Accident Recirculation Line

Figure G-1. Reactor containment arrangement, Arkansas Unit 2

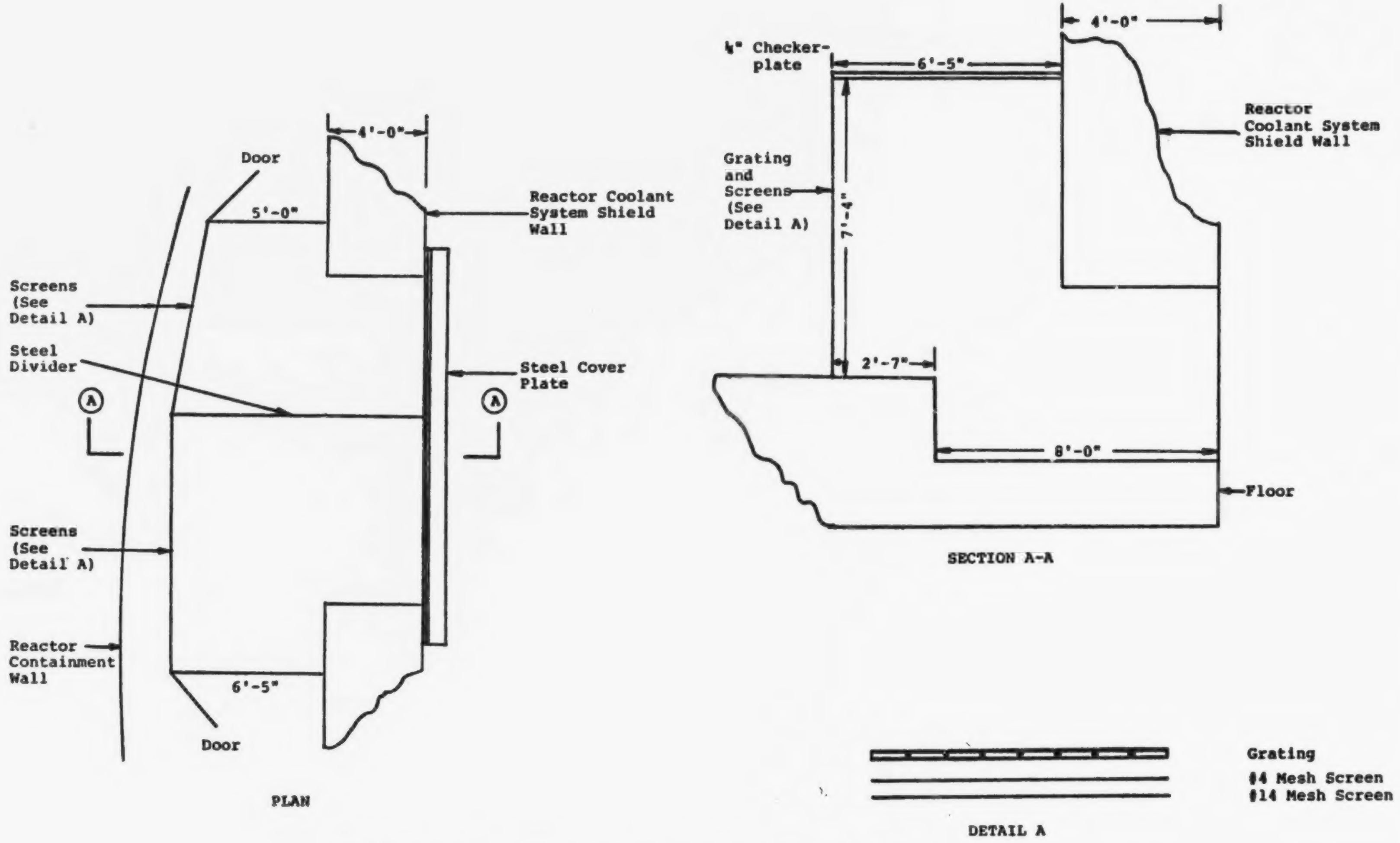
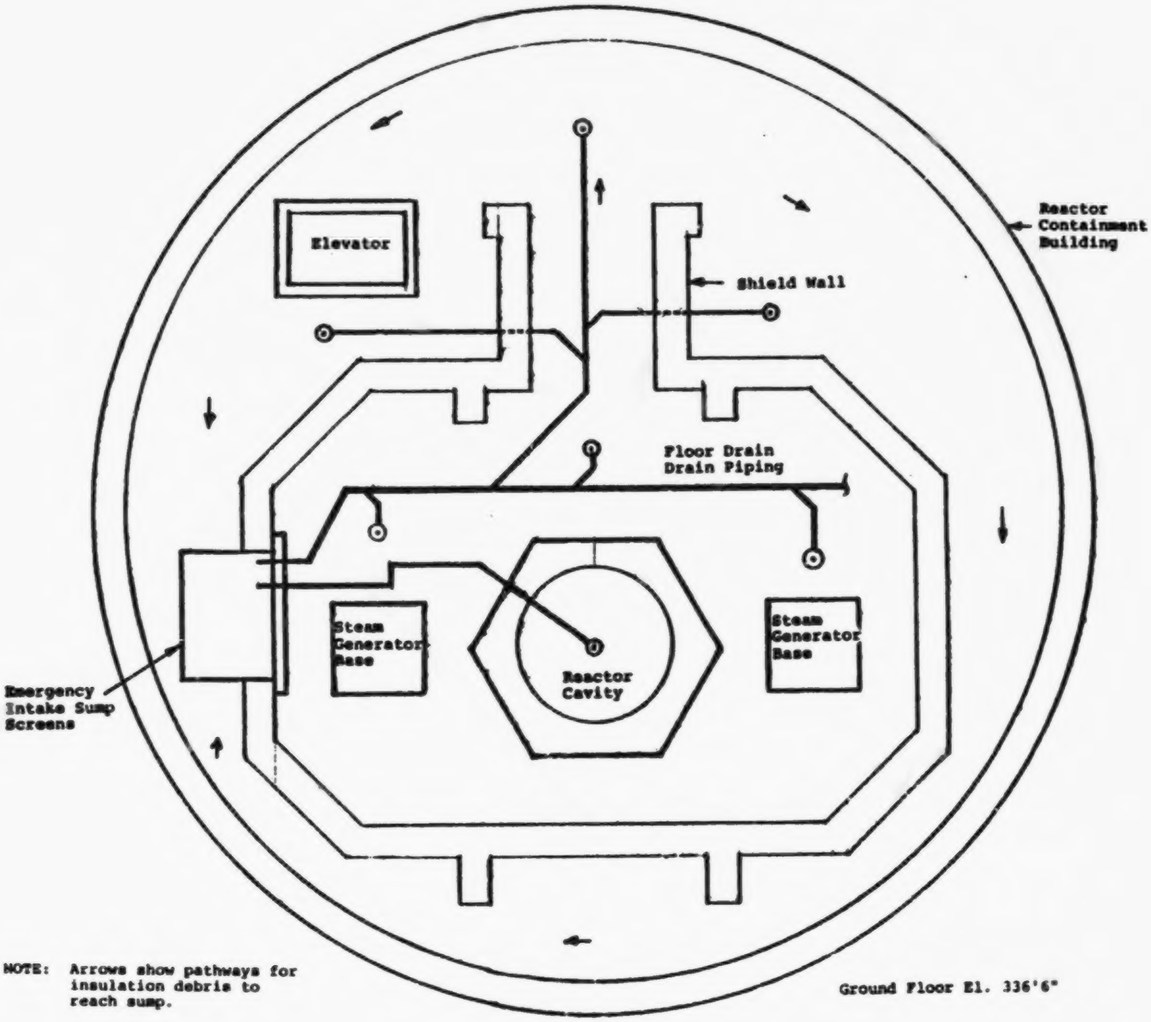

4'-0"
Door
5'-0"
Reactor Coolant System Shield Wall
Screens (See Detail A)
Steel Divider
A
A
Steel Cover Plate
Screens (See Detail A)
Reactor Containment Wall
6'-5"
Door
PLAN
4'-0"
¼" Checker-plate
6'-5"
Reactor Coolant System Shield Wall
Grating and Screens (See Detail A)
7'-4"
2'-7"
8'-0"
Floor
SECTION A-A
Grating
#4 Mesh Screen
#14 Mesh Screen
DETAIL A

Figure G-2. Emergency intake sump, Arkansas Unit 2


Reactor Containment Building
Elevator
Shield Wall
Floor Drain Drain Piping
Steam Generator Base
Steam Generator Base
Reactor Cavity
Emergency Intake Sump Screens

NOTE: Arrows show pathways for insulation debris to reach sump.

Ground Floor El. 336'6"

SCALE

0 25' 50'

TYPE OF INSULATION INSIDE PRIMARY COOLANT SYSTEM SHIELD WALL	APPROXIMATE QUANTITY FT^2
Reflective Metallic	6,300
Encapsulated Calcium Silicate/Perlite	7,400
Covered Fiberglass	200

Figure G-3. Pathways of insulation debris to emergency intake sump, Arkansas Unit 2

APPENDIX H

WATERFORD UNIT 3:

PRELIMINARY ASSESSMENT OF INSULATION DEBRIS GENERATED DURING A PIPE BREAK EVENT

A. INTRODUCTION

This report documents the information gathered by Burns and Roe's survey of thermal insulation inside the primary containment of the 1165 MWe, Combustion Engineering PWR, Waterford Unit 3, which is scheduled for commercial operation in 1983.

The information gathered depicts the following:

1. The arrangement of all piping within the primary containment including high energy fluid piping
2. The location and configuration of the emergency intake sump for emergency core cooling; and the communicating paths by which debris generated by a major pipe break could reach the emergency recirculating sump
3. Details of the insulation that could be dislodged and become a source of debris as a result of a major break

According to information provided by Ebasco Services Inc., the engineers for Waterford Unit 3, encapsulated fiberglass insulation is used for all equipment and piping needing insulation inside the primary containment with the exception of the reactor vessel. The reactor vessel is insulated with reflective metallic insulation.

B. LISTING OF INPUT DRAWINGS AND OTHER DOCUMENTS

This section provides a listing of drawings and documentation showing details of the containment and emergency sump design, flow diagrams for insulated systems inside containment, piping layout drawings for piping containing insulation inside containment, plumbing drawings for inside containment, and structural drawings showing platforms inside containment.

1. Documentation

   a. Specification LOU-1564.101 — Heat, Antisweat, and Process Heating Insulation

   b. List of Type of Insulation Inside Primary Containment

   c. Section 6.2.2.2.2.1 of the FSAR titled "SIS Sump Design"

2. Drawings

   a. General Arrangment - Containment and Reactor Building

   LOU-1564 G-143 — General Arrangement Reactor Bldg Plan El. +46.00'

LOU-1564 G-144	General Arrangement Reactor Bldg Plan El. +21.00'
LOU-1564 G-145	General Arrangement Reactor Bldg Plan El. -4.00'
LOU-1564 G-146	General Arrangement Reactor Bldg Section Sh.1
LOU-1564 G-147	General Arrangement Reactor Bldg Section Sh. 2
LOU-1564 G-148	General Arrangement Reactor Bldg Section Sh. 3
LOU-1564 G-763	Floor Plans Sh. 1
LOU-1564 G-764	Floor Plans Sh. 2
LOU-1564 G-765	Floor Plans Sh. 3 and 4
LOU-1564 G-767	Elevations Sh. 1
LOU-1564 G-768	Elevations Sh. 2

b. Emergency Sump Design Details

LOU-5817 G-702	Reactor Building Screens Safety Injection System

c. Reactor Building Plumbing and Drainage

LOU-1564 G-885	Reactor Building Plan El. 4.00' Plumbing and Drainage
LOU-1564 G-886	Reactor Building Plan El. 21.00' Plumbing and Drainage
LOU-1564 G-887	Reactor Building Plan El. 46.00' Plumbing and Drainage
LOU-5817 G-932	Flow Diagram -Reactor, Turbine and Fuel Handling Buildings Drainage Systems Plumbing and Drainage

d. Flow Diagrams for Insulated Systems Inside Containment

E-9270-210-110	Reactor Coolant System P&I Diag
LOU-1564 G-164	Miscellaneous Reactor Auxiliary Systems Sh. 1 of 3
LOU-1564-G-163	Flow Diagram Containment Spray and Refueling Water Storage Pool
LOU-1564 G-162	Flow Diagram Sampling System Sh. 1 and 2
LOU-1564 G-160	Flow Diagram Component Closed Cooling Water System Sh. 2 of 2
LOU-1564 G-153	Flow Diagram Feedwater, Condensate and Air Evacuation Systems Sh. 1 and Sh. 2
LOU-1564 G-151	Flow Diagram Main and Extraction Steam Systems Sh. 1 of 2

LOU-1564 G-179	Flow Diagram Reactor Coolant Pump Seals
LOU-1564 G-172	Flow Diagram Reactor Coolant System
LOU-1564 G-171	Flow Diagram Boron Management System Sh. 1 of 2
LOU-1564 G-168	Flow Diagram Chemical and Volume Control System Sh. 1 and Sh. 2
LOU-1564 G-167	Flow Diagram Safety Injection System Sh. 1 and Sh. 2

e. Piping Layout Drawings

E-9270-210-201	Reactor Coolant System Arrangement Elevation
E-9270-210-200	Reactor Coolant System Arrangement Plan
LOU-1564 G-176	Main Steam and Feedwater Piping Sh. 1 of 6
LOU-1564 G-194	Chemical and Volume Control Piping Sh. 4 of 4
LOU-1564 G-195	Safety Injection System Piping Sh. 2 of 8 Sh. 4 of 8 Sh. 7 of 8 Sh. 8 of 8
LOU-1564 G-197	Boron Management Piping Sh. 3 of 4
LOU-1564 G-204	Reactor Auxiliary and Containment Building - Miscellaneous Piping Sh. 1 of 7 Sh. 3 of 7 Sh. 7 of 7
LOU-1564 G-206	Nuclear Sampling Piping
LOU-4294 G-022	Reactor Building 2" and Under Non Seismic Piping El 35.00' Sh. 1 of 13

f. Reactor Building Platform Drawings

LOU-1564 G-801A	Reactor Building Platforms Sh. 1 El. -4.00'
LOU-1564 G-801B	Reactor Building Platforms Sh. 2 El. -4.00'
LOU-1564 G-802A	Reactor Building Platforms Sh. 3 El. +21.00'
LOU-1564 G-802B	Reactor Building Platforms Sh. 4 El. +21.00'
LOU-1564 G-802C	Reactor Building Platforms Sh. 5 Sections and Details

LOU-1564 G-802D	Reactor Building Platforms Sh. 6 El. +46.00
LOU-1564 G-802E	Reactor Building Platforms Sh. 7 El. +46.00'
LOU-1564 G-802F	Reactor Building Platforms Sh. 8 Sections and Details

C. LISTING OF PIPING INSIDE CONTAINMENT CONTAINING INSULATION

This section provides a list of the systems inside primary containment containing insulation. The list includes the system, nominal pipe sizes inside containment, and the type of insulation used for each system.

System	Nominal Pipe Sizes (inches)	Type of Insulation
Reactor Coolant	30	Encapsulated fiberglass
Safety Injection	12, 8, 3	Encapsulated fiberglass
Pressurizer Surge Line	12	Encapsulated fiberglass
Pressurizer Spray Line	4, 3	Encapsulated fiberglass
Pressurizer Relief Lines	12, 6	Encapsulated fiberglass
Main Steam Piping	34	Encapsulated fiberglass
Feedwater	20	Encapsulated fiberglass
Steam Generator Blowdown	4	Encapsulated fiberglass
Decay Heat Removal	12, 2	Encapsulated fiberglass
Chemical Volume and Control	3, 2, 3/4	Encapsulated fiberglass
Sampling	1	Encapsulated fiberglass

D. TYPICAL INSULATION DETAILS

Reflective metallic insulation manufactured by Transco is used for the reactor vessel. Encapsulated fiberglass also manufactured by Transco is used for all other insulated equipment and piping inside the containment building.

The reflective metallic insulation is in Appendix A of this report. The construction of the encapsulated fiberglass insulation is exactly the same as that of reflective, except that a non-reflective material is used between the inner and outer casings instead of stainless steel or aluminum.

The insulation has only recently been selected and vendor drawings are not yet available.

E. PIPE BREAK LOCATIONS

Refer to the FSAR[1] for a list of the pipe break locations for high energy piping inside the primary containment.

F. FSAR REFERENCES ON PERTINENT INSULATION QUESTIONS

Refer to Section 6.2.2.2.1 of the FSAR that describes the emergency sump design.

G. PRELIMINARY INSULATION DEBRIS HAZARD ANALYSIS

Figures H-1 and H-2 are simplified sketches of Waterford Unit 3 reactor containment. The reactor vessel, steam generators, pressurizer, and associated piping are all located inside the shield wall. The emergency sump is located outside the shield wall below the basement floor at elevation -16.00' as shown in Figure H-2.

Figure H-3 shows the details of the emergency intake sump. The sump is surrounded by a screen (5' high and 17'-8" wide) in front of which are coarse blankets (3' high and 3' wide). The screen is constructed of 18-gauge wire mesh spaced at 8 wires per inch with a clear opening of 0.078". The baskets are 80 mesh stainless steel. The emergency sump is provided with two separate inlets, one for each half of the emergency core-cooling and containment spray system. No high-energy systems are located near the emergency sump; therefore, the sump screens cannot be damaged by whipping pipes or high-velocity jets.

A pipe break in a primary coolant line could cause a large amount of steam generator and primary coolant piping insulation to become dislodged and fall to the bottom of the steam generator cell. At the basement floor (elevation -11'-0"), large openings in the shield wall could allow insulation that floats to migrate to the emergency intake sump (see Figure H-4). Encapsulated fiberglass insulation is used for the steam generator and primary coolant piping.

For piping outside the shield wall, the potential for a large amount of insulation to migrate towards the emergency sump does not exist. Platforms at elevations 46', 21', and 4' would catch most of the insulation dislodged from high-energy pipe breaks.

H. REFERENCES

1. Waterford 3, Final Safety Analysis Report, Louisiana Power & Light Company, New Orleans, Louisiana.

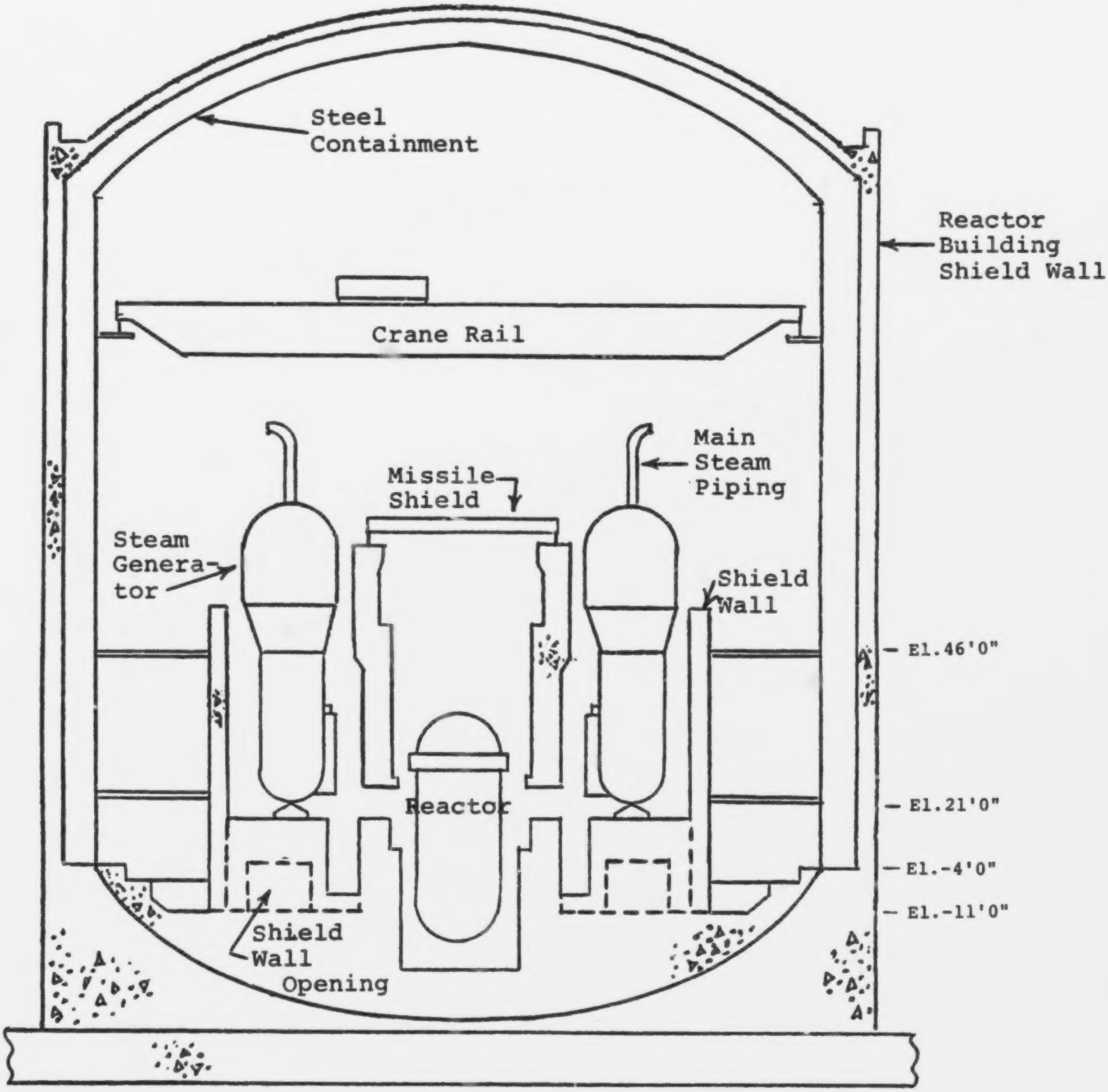

Steel Containment
Reactor Building Shield Wall
Crane Rail
Main Steam Piping
Missile Shield
Steam Generator
Shield Wall
El.46'0"
Reactor
El.21'0"
El.-4'0"
El.-11'0"
Shield Wall Opening

Figure H-1. Reactor containment arrangement, Waterford Unit 3

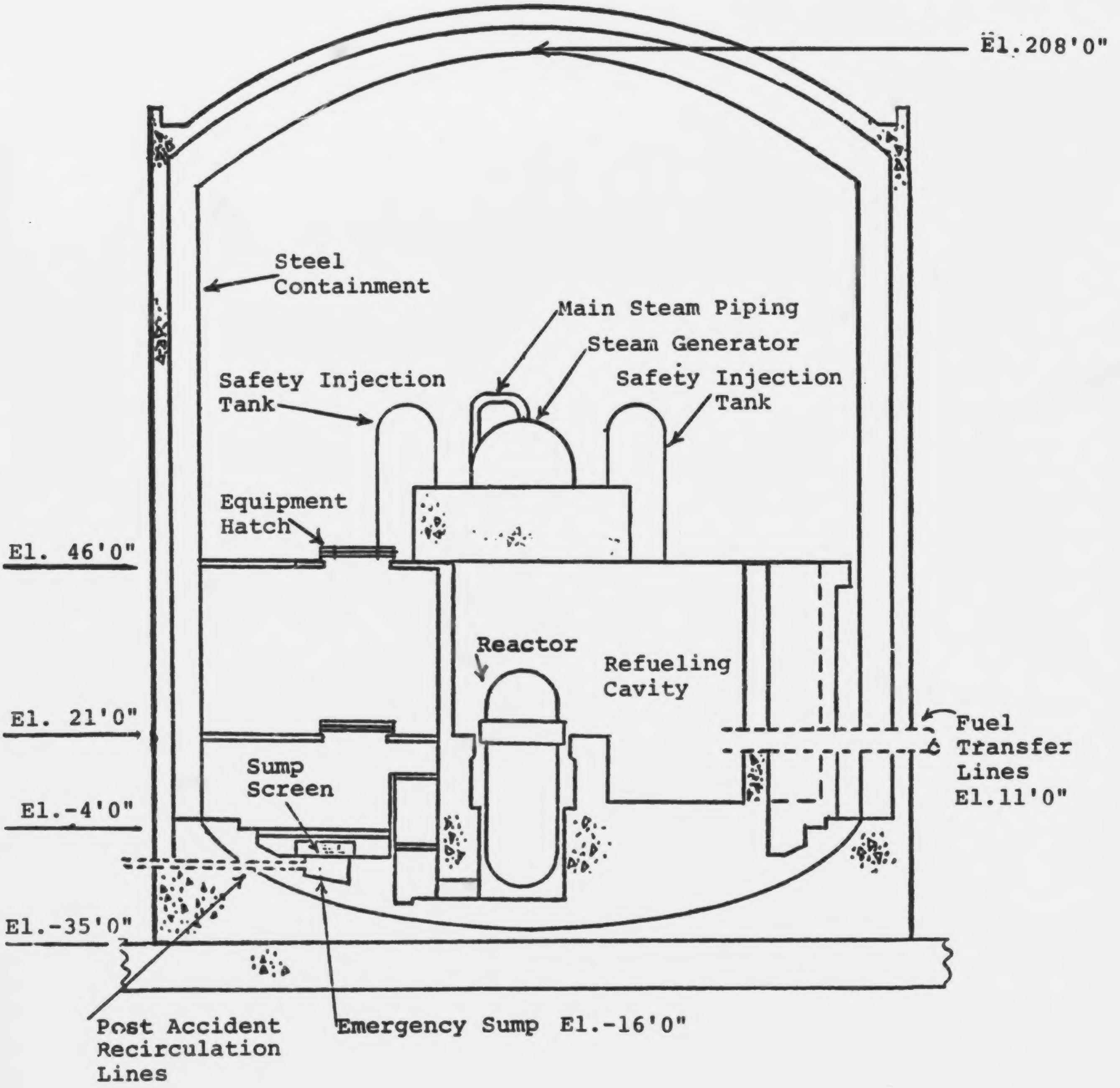

El.208'0"
Steel
Containment
Main Steam Piping
Steam Generator
Safety Injection
Tank
Safety Injection
Tank
Equipment
Hatch
El. 46'0"
Reactor
Refueling
Cavity
El. 21'0"
Fuel
Transfer
Lines
El.11'0"
Sump
Screen
El.-4'0"
El.-35'0"
Post Accident
Recirculation
Lines
Emergency Sump El.-16'0"

Figure H-2. Reactor containment arrangement with sump location, Waterford Unit 3

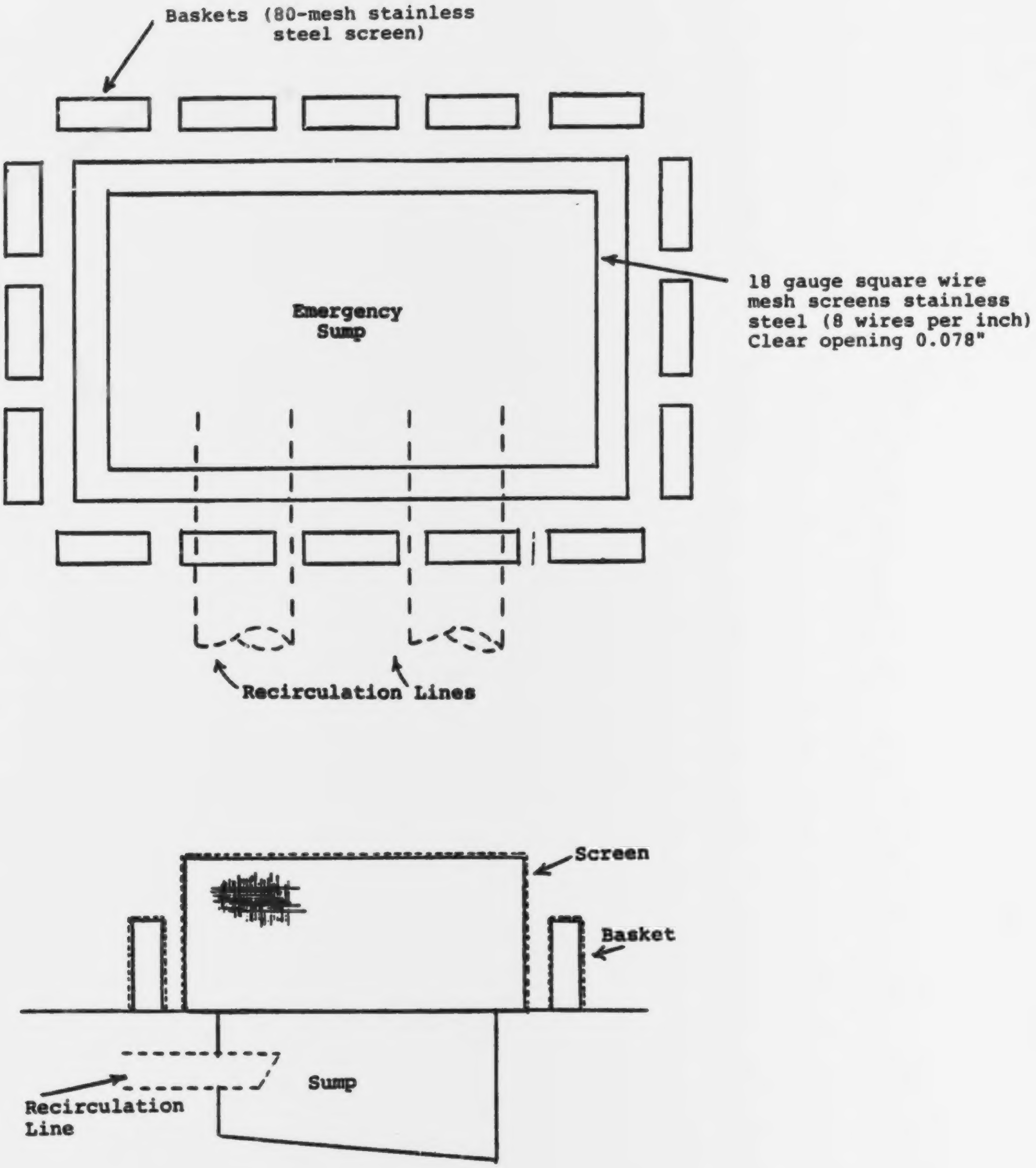
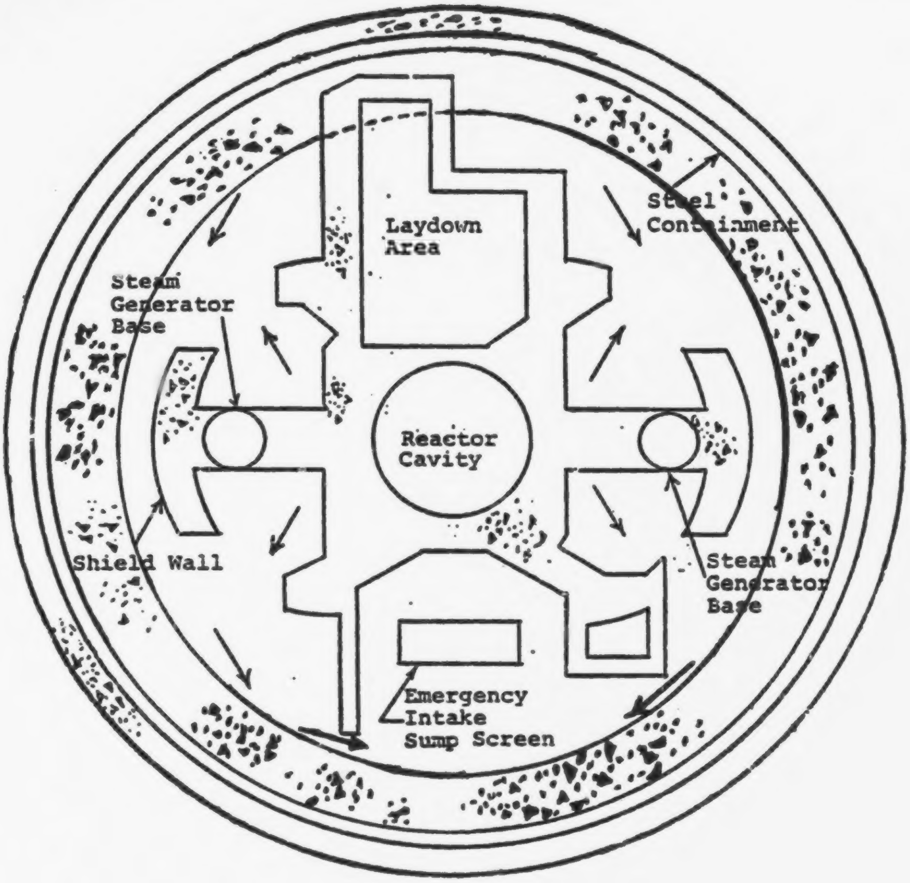

Baskets (80-mesh stainless steel screen)
Emergency Sump
18 gauge square wire mesh screens stainless steel (8 wires per inch) Clear opening 0.078"
Recirculation Lines
Screen
Basket
Sump
Recirculation Line

Figure H-3. Emergency intake sump, Waterford Unit 3


Laydown Area
Steel Containment
Steam Generator Base
Reactor Cavity
Shield Wall
Steam Generator Base
Emergency Intake Sump Screen

NOTE: Arrows show pathways for insulation debris to reach sump.

El. 11′ 0″

TYPE OF INSULATION INSIDE PRIMARY COOLANT SYSTEM SHIELD WALL	APPROXIMATE QUANTITY FT^2
Reflective Metallic	2,300
Encapsulated Fiberglass	15,500

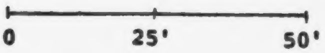


Figure H-4. Pathways of insulation debris to emergency intake sump, Waterford Unit 3

APPENDIX I

SALEM UNIT 1:

PRELIMINARY ASSESSMENT OF INSULATION DEBRIS GENERATED DURING A PIPE BREAK EVENT

A. INTRODUCTION

This report documents the information gathered by Burns and Roe's survey of thermal insulation inside the primary containment of the 1090 MWe, Westinghouse PWR, Salem Unit 1, which started commercial operation in 1977.

The information gathered depicts the following:

1. The arrangement of all piping within the primary containment including high energy fluid piping
2. The location and configuration of the emergency intake sump for emergency core cooling and the communicating paths by which debris generated by a major pipe break could reach the emergency recirculating sump
3. Details of the insulation that could be dislodged and become a source of debris as a result of a major break

According to Public Service Electric and Gas (PSE&G) Company, reflective metallic insulation is used for the primary coolant system, reactor vessel, coolant pumps, pressurizer, and the bottom area of the steam generators up to one foot above the tube sheets. The upper part of the steam generator uses semi-encapsulated cerablanket insulation, a ceramic fibrous material composition. For systems connected to the primary system out to the first isolation valve, reflective insulation is used. After the first isolation valve, totally encapsulated Cerablanket (Johns-Manville product) is used.

B. LISTING OF INPUT DRAWINGS AND OTHER DOCUMENTS

This section provides a listing of drawings and documents showing details of the containment and reactor building, emergency drainage and sump, piping flow diagrams, and structural drawings obtained from PSE&G.

Piping drawings and insulation drawings were not provided by PSE&G.

1. Documentation
   - a. Docket No: 50-311 Letter dated July 21, 1980 from A. Schwencer, Acting Chief Licensing Branch No. 3, Division of Licensing and Environment, PSE&G, titled Request for Additional Information-Sump Performance.
   - b. Docket No: 50-311 Letter dated September 17, 1980 from R. L. Mittl, PSE&G to F. J. Miraglia, Chief Licensing Branch 3, Additional Information Containment Sump Performance Unit No. 2.
   - c. Telecon dated March 10, 1981 from R. Reyer, Burns and Roe to C. Wagner, Insulation used for Piping and Equipment inside Reactor Containment Salem Unit 1.

2. Drawings

a. General Arrangement - Reactor Containment

204804 A-8752	Auxiliary Building, Reactor Containment and Fuel Handling Area - El. 100'
204805 A-8752	Auxiliary Building - El. 84' Reactor Containment - El. 78'-8" and 81' Fuel Handling Area -El. 85' and 89' -6"
204807 A-8752	Auxiliary Building and Reactor Containment - El. 45' and 55'
204808 A-8752	Auxiliary Building and Reactor Containment Section A-A
204809 A-8752	Auxiliary Building and Reactor Containment Section B-B and C-C

b. Emergency Sump Design Details

208915 A-8823	No. 1 & 2 Units - Reactor Containment Drainage Trench - El. 81' and 78' Sump Pit - El. 54-'6" and 72'-7"

c. Flow Diagrams for Insulated Systems Inside Containment

205301 A-8762	Reactor Coolant
205302 A-8762	Steam Generator Feed and Condensate
205303 A-8762	Main, Reheat and Turbine By-pass Steam
205325 A-8763	Steam Generator Drains and Blowdown
205328 A-8763	Chemical and Volume Control
205329 A-8763	Chemical and Volume Control Boric Acid Recovery
205330 A-8763	Chemical and Volume Control Primary Water Recovery
205331 A-8763	Component Cooling
205332 A-8763	Residual Heat Removal
205334 A-8763	Safety Injection
205335 A-8763	Containment Spray
205336 A-8763	Auxiliary Feedwater
205338 A-8763	Reactor Containment Ventilation
205338 A-8763	Service Water Nuclear Area

d. Piping Layout Drawings

None were submitted.

e. Insulation Drawings

None were submitted.

f. Structural Drawings

201111 A-8707	Reactor Containment Slab - El. 78'-0" and El. 81'
201116 A-8707	Reactor Containment Internal Walls and Reactor Fdn Plan - El. 90'-0"
201117 A-8707	Reactor Containment Internal Walls and Reactor Fdn Plan - El. 94'-0"
201118 A-8707	Reactor Containment Internal Walls and Reactor Fdn Plan - El. 104'-0"
201120 A-8707	Reactor Containment Internal Walls and Reactor Fdn Sections, Sheet 1
201121 A-8707	Reactor Containment Internal Walls and Reactor Fdn Sections, Sheet 2
201122 A-8707	Reactor Containment Reactor Pit, Sheet 1
201123 A-8707	Reactor Containment Reactor Pit, Sheet 2
201124 A-8707	Reactor Containment Reactor Pit, Sheet 3

C. LISTING OF PIPING INSIDE CONTAINMENT CONTAINING INSULATION

This section provides a list of the equipment and piping systems inside primary containment containing insulation. The list includes the equipment, the system, nominal pipe sizes inside containment, and the type of insulation used for each system.

System	Nominal Pipe Size (inches)	Type of Insulation
Reactor Coolant	31, 29, 27-1/2	Reflective Metallic
Pressurizer Surge Line	14	Reflective Metallic
Safety Injection	10, 6, 4, 2, 1-1/2	Reflective Metallic
Main Steam	27-3/4	Reflective Metallic/ Encapsulated Cerablanket
Feedwater	14, 4	Reflected Metallic/ Encapsulated Cerablanket
Residual Heat Removal	14, 12, 8	Reflective Metallic/ Encapsulated Cerablanket
Chemical, Volume and Control	4, 3, 2, 1-1/2	Reflective Metallic/ Encapsulated Cerablanket
Service Water	Various	Antisweat
Component Cooling Water	Various	Antisweat

Reflective metallic insulation is used for the reactor vessel, reactor coolant pump, pressurizer, and bottom area of the steam generators to one foot above the tube sheet. The upper part of the steam generator uses semi-encapsulated cerablanket with stainless steel lagging. For systems connected to the primary coolant system, metallic reflective insulation is used out to the first isolation valve. After the first isolation valve, totally encapsulated Cerablanket (Johns-Manville product) is used for the safety injection, main steam, feedwater, residual heat removal, and chemical volume and control piping. Service water and component cooling-water piping inside containment is insulated with antisweat insulation. Information on the type of antisweat insulation used was not provided to Burns and Roe.

D. TYPICAL INSULATION DETAILS

The reflective metallic insulation used for primary coolant system equipment and piping was manufactured by Johns-Manville. It is similar in construction to the reflective insulation manufactured by Mirror and Transco.

E. PIPE BREAK LOCATIONS

Refer to the FSAR[1] for a list of the pipe break locations for high-energy piping inside the primary containment.

F. FSAR REFERENCES ON PERTINENT INSULATION QUESTIONS

None were submitted by PSE&G.

G. PRELIMINARY INSULATION DEBRIS HAZARD ANALYSIS

Figures I-1 and I-2 are simplified sketches of the Salem Unit 1 containment. The reactor vessel, lower part of the steam generators, pressurizer, reactor coolant pumps, and primary coolant piping are all located inside the shield wall. The accumulators, letdown heat exchanger, and regenerative heat exchangers are located outside the primary coolant shield wall. The emergency sump is located outside the shield wall below the basement floor at elevation 76'-10" as shown in Figure I-1. Figure I-3 shows the details of the emergency sump. Figures I-1 and I-2 show the drainage trenches in the containment building. There are two trenches that are located in an inscribed circle around the building; one trench located inside the primary coolant shield wall and another trench located outside the primary coolant shield wall. Water drains into the trench through perforated pans with 3/16" diameter holes staggered on 5/16" centers. The outer trench drains into the sump through a 16" diameter pipe. The inner trench drains into the outer trench through a 12" diameter pipe. Both trenches are sloped toward the sump. The sump is covered with a solid steel plate so that all water reaching the sumps must enter through the drainage trenches. The RHR recirculation piping is protected from debris by the 3/16" diameter holes in perforated trench pans.

For a pipe break event near the upper portion of the steam generators, the floor at elevation 130' will catch the insulation debris. For a pipe break event inside the primary coolant shield wall, the reflective metallic insulation would sink and possible cover some of the perforated trench pans inside the shield wall. Blockage of a number of trench pans would not affect the ability of the water to drain into the recirculation sump since the building is ringed with trenches and the water has a number of paths to leave the shield area and find its way towards the drainage trench.

For a pipe break event outside the shield wall, the encapsulated Cerablanket insulation would probably float. As such it could not find its way into the drainage trench and would not affect the emergency recirculation sump.

H. REFERENCE

1. Salem 1, Final Safety Analysis Report, Public Service Electric & Gas Company, Newark, New Jersey

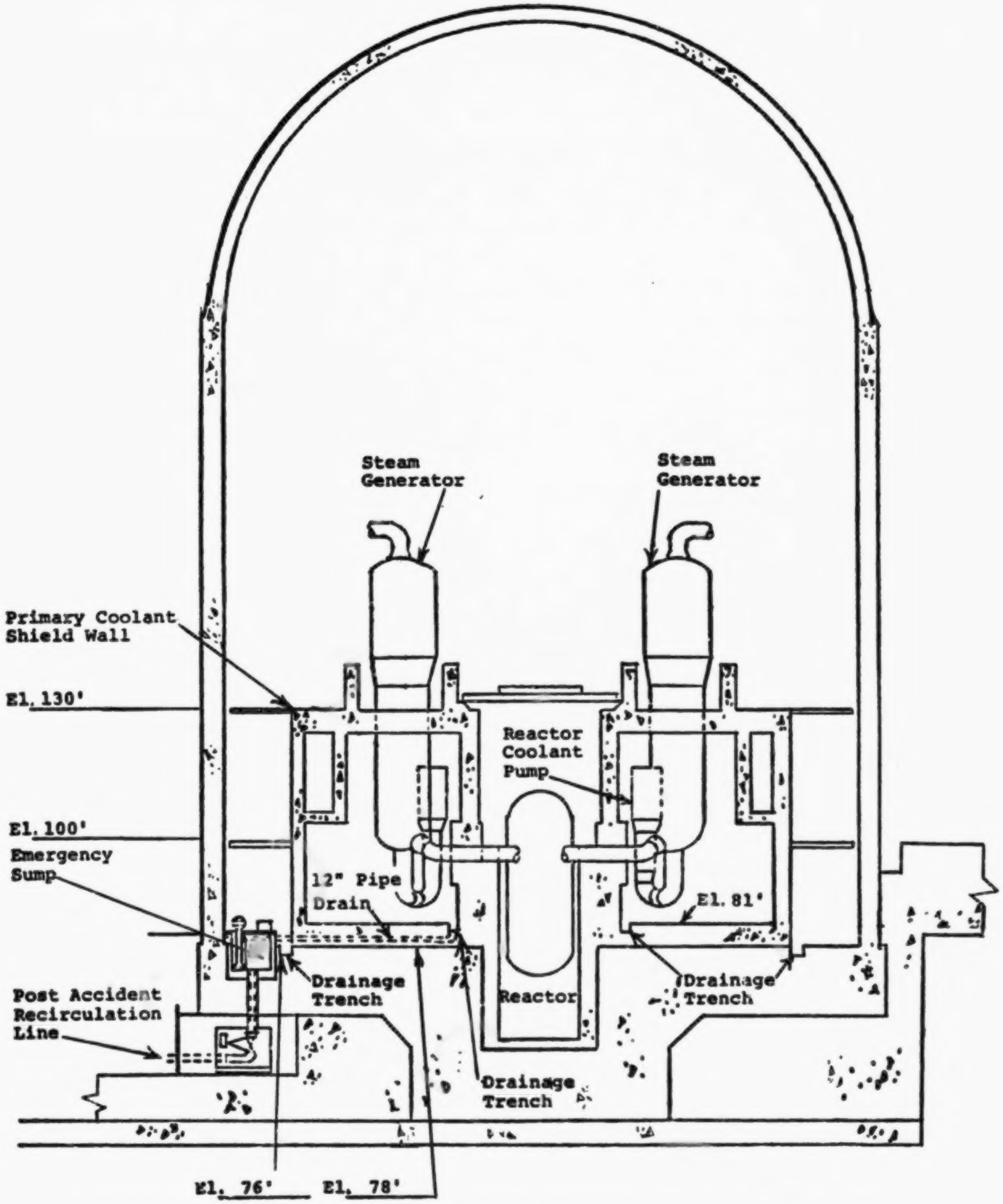
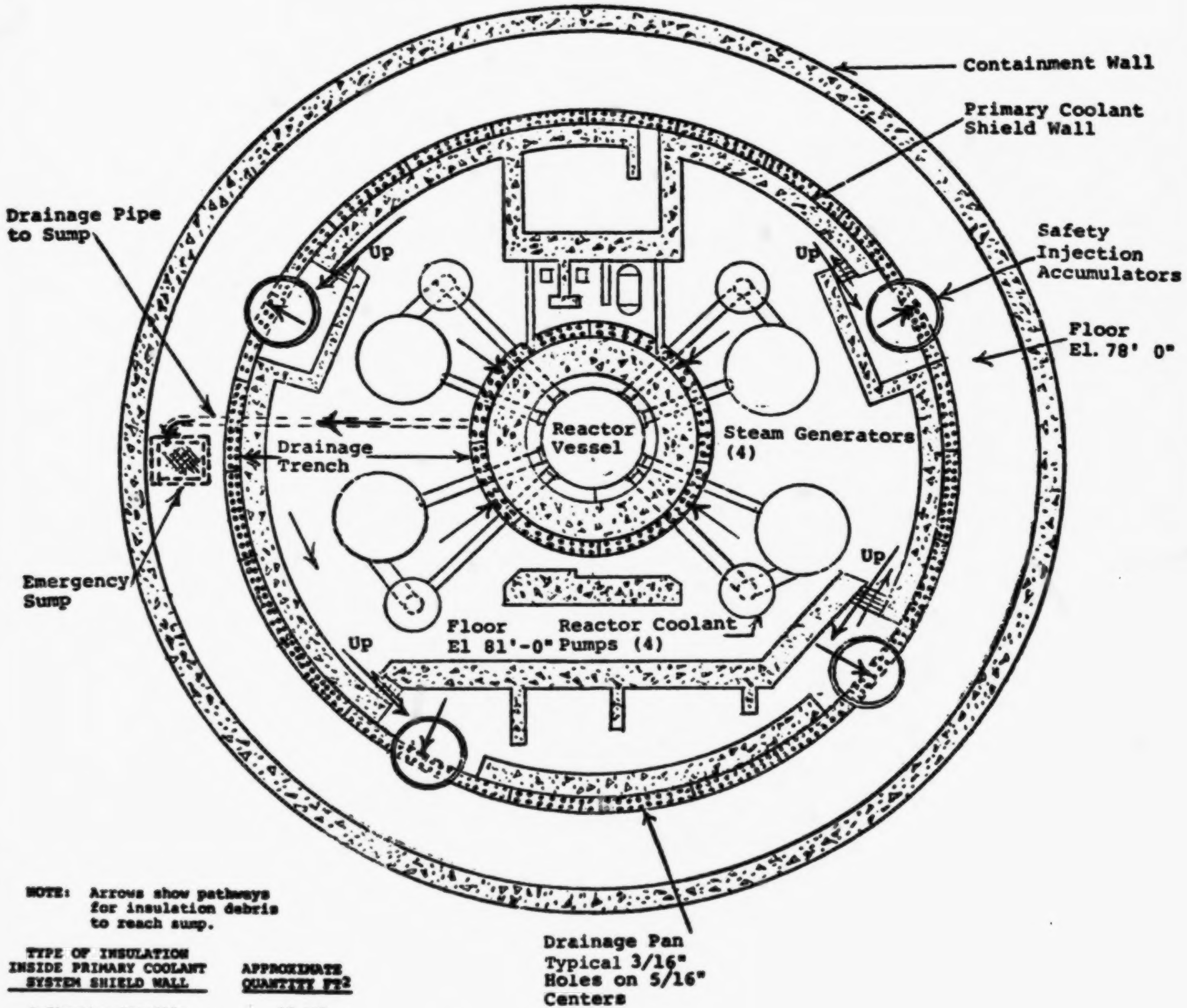

Steam Generator
Steam Generator
Primary Coolant Shield Wall
El. 130'
Reactor Coolant Pump
El. 100'
Emergency Sump
12" Pipe Drain
El. 81'
Drainage Trench
Drainage Trench
Reactor
Post Accident Recirculation Line
Drainage Trench
El. 76'
El. 78'

Figure I-1. Reactor containment arrangement, Salem Unit 1


Containment Wall
Primary Coolant Shield Wall
Drainage Pipe to Sump
Up
Up
Safety Injection Accumulators
Floor El. 78' 0"
Reactor Vessel
Steam Generators (4)
Drainage Trench
Emergency Sump
Up
Floor El 81'-0"
Reactor Coolant Pumps (4)
Up
Drainage Pan Typical 3/16" Holes on 5/16" Centers

NOTE: Arrows show pathways for insulation debris to reach sump.

TYPE OF INSULATION INSIDE PRIMARY COOLANT SYSTEM SHIELD WALL	APPROXIMATE QUANTITY FT^2
Reflective Metallic	17,100
Encapsulated Cerablanket	3,400
Mineral Wool	23,300

Figure I-2. Reactor containment arrangement plan view, Salem Unit 1

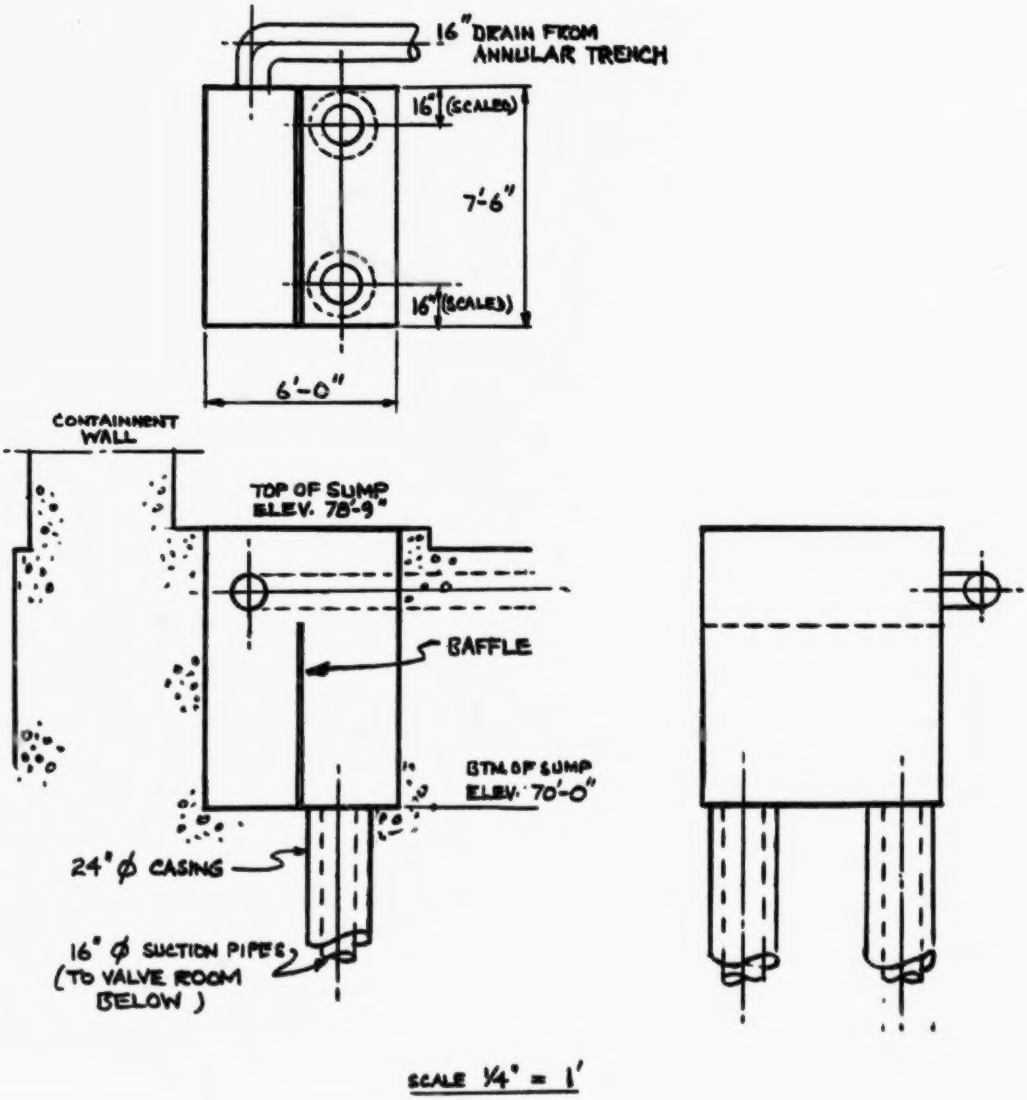

16" DRAIN FROM ANNULAR TRENCH
16" (SCALED)
7'-6"
16" (SCALED)
6'-0"
CONTAINMENT WALL
TOP OF SUMP ELEV. 78'-9"
BAFFLE
BTM. OF SUMP ELEV. 70'-0"
24" ø CASING
16" ø SUCTION PIPES (TO VALVE ROOM BELOW)
SCALE 1/4" = 1'

Figure I-3. Emergency sump detail, Salem Unit 1

APPENDIX J

SEQUOYAH UNIT 2:

PRELIMINARY ASSESSMENT OF INSULATION DEBRIS GENERATED DURING A PIPE BREAK EVENT

A. INTRODUCTION

This report documents the information gathered by Burns and Roe's survey of thermal insulation inside the primary containment of the 1148 MWe, Westinghouse PWR, Sequoyah Unit 2 which is scheduled to start commercial operation in 1982.

The information gathered depicts the following:

1. The arrangement of all piping within the primary containment including high energy fluid piping
2. The location and configuration of the emergency intake sump for emergency core cooling, and the communicating paths by which debris generated by a major pipe break could reach the emergency recirculation sump
3. Details of the insulation that could be dislodged and become a source of debris as a result of a major break

According to Tennessee Valley Authority (TVA), reflective metallic insulation, manufactured by Mirror Insulation, is used exclusively within the shielded crane wall area for both equipment and piping. Outside the shield wall area, the ice condenser refrigerant lines are insulated with Foamglass, the ice condenser piping is insulated with Rubatex, the piping inside the air handling units with fiberglass, the wall panel insulation between steel air-cooling ducts and the steel containment shell is insulated with polyurethane foam, the top deck of the ice condenser with polyurethane foam, the ice condenser doors with urethane foam, and the main pipe penetrations of the containment vessel with mineral wool.

B. LISTING OF INPUT DRAWINGS AND OTHER DOCUMENTS

This section provides a listing of drawings and documents showing details of the containment and reactor building, composite piping, emergency sump design, and insulation details obtained from TVA and NRC. General arrangement drawings; flow diagrams; structural, platform, and plumbing drawings were not obtained from TVA. The Sequoyah FSAR was used for general arrangement and flow diagram information.

1. Documentation

a. Letter from L. M. Mills, TVA, Manager Nuclear Regulation and Safety to A. Schwencer, Chief Lightwater Reactors Branch No. 2 Division of Licensing USNRC dated July 21, 1980, "Request Additional Information Containment Sump" Report No. WM28-1-45-102

b. Model Study of the Sequoyah RHR Sump by Theodoric G. Fain TVA Division of Water Management Water Systems Development Branch dated October 1978

2. Drawings

   a. General Arrangements-Containment and Reactor Building

      Refer to Sequoyah FSAR

   b. Emergency Sump Design Details

      Refer to the Model Study of the Sequoyah RHR Sump noted under B.1 Documentation.

   c. Flow Diagrams for Insulated Systems Inside Containment

      Refer to Sequoyah FSAR

   d. Piping Layout Drawings (As-Built Drawings)

45-M-4-47W2500-1	Reactor Building - Unit 1 Composite Piping - Quad I Inside Crane Wall - El. 679'-9 1/2" to 701'-0" Outside Crane Wall - El. 679'-9 1/2" to 691'-0"
45-M-4-47W2500-2	Reactor Building - Unit 1 Composite Piping - Quad II Inside Crane Wall - El. 679'-9 1/2" to 701'-0" Outside Crane Wall - El. 679'-9 1/2" to 691'-0"
45-M-4-47W2500-3	Reactor Building - Unit 1 Composite Piping - Quad III Inside Crane Wall - El. 679'-9 1/2" to 701'-0" Outside Crane Wall - El. 679'-9 1/2" to 691'-0"
45-M-4-47W2500-4	Reactor Building - Unit 1 Composite Piping - Quad IV Inside Crane Wall - El. 679'-9 1/2" to 701'-0" Outside Crane Wall - El. 679'-9 1/2" to 691'-0"
4-M-4-47W2500-5	Reactor Building - Unit 1 Composite Piping - Quad I Inside Crane Wall - El. 701'-0" to 711'-0" Outside Crane Wall - El. 693'-0" to 711'-0"

45-M-4-47W2500-6	Reactor Building - Unit 1 Composite Piping - Quad II Inside Crane Wall - El. 701'-0" to 711'-0" Outside Crane Wall - El. 693'-0" to 711'-0"
4-M-4-47W2500-7	Reactor Building - Unit 1 Composite Piping - Quad III Inside Crane Wall - El. 701'-0" to 711'-0" Outside Crane Wall - El. 693'-0" to 711'-0"
45-M-4-472500-8	Reactor Building - Unit 1 Composite Piping - Quad IV Inside Crane Wall - El. 701'-0" to 711'-0" Outside Crane Wall - El. 693'-0" to 711'-0"
45-M-4-47W2500-9	Reactor Building - Unit 1 Composite Piping - Quad I Inside Crane Wall - El. 711'-0" to 731'-6" Outside Crane Wall - El. 711'-0" to 719'-6"
45-M-4-47W2500-10	Reactor Building - Unit 1 Composite Piping - Quad II Inside Crane Wall - El. 711'-0" to 731'-6" Outside Crane Wall - El. 711'-0" to 719'-6"
45-M-4-47W2500-11	Reactor Building - Unit 1 Composite Piping - Quad III Inside Crane Wall - El. 711'-0" to 731'-6" Outside Crane Wall - El. 711'-0" to 719'-6"
45-M-4-47W2500-1	Reactor Building - Unit 1 Composite Piping - Quad IV Inside Crane Wall - El. 711'-0" to 731'-6" Outside Crane Wall - El. 711'-0" to 719'-6"

e. Reflective Metallic Insulation Drawings

None were submitted by TVA.

C. LISTING OF PIPING INSIDE CONTAINMENT CONTAINING INSULATION

This section provides a list of the piping systems inside primary containment containing insulation. The list includes the system, nominal pipe sizes inside containment, and the type of insulation used for each system.

System	Nominal Pipe Sizes (Inches)	Type of Insulation
Reactor coolant	29,27-1/2,31	Reflective metallic
Residual heat removal	6,14	Reflective metallic
Safety injection	6,8,10	Reflective metallic
Main steam	32	Reflective metallic
Feedwater	16	Reflective metallic
Ice condenser piping	6,12	Antisweat

Reflective metallic insulation is used on the reactor vessel, steam generators, pressurizer, and reactor coolant pumps.

D. TYPICAL INSULATION DETAILS

The following descriptions of the insulation used were provided by TVA.

Mirror Insulation

Mirror insulation is an all-metal reflective insulation constructed of austenitic stainless steel. The metallic reflective insulation is strong mechanically and composed of sections which are latched together when in place. The sections will not segment or break up into small particles. The sections will sink to the bottom and will remain stationary. Insulation in the vicinity of the pipe break will be blown or stripped off. It is not considered that the sections would be torn apart due to their strong mechanical construction.

Foamglass Insulation

Foamglass insulation is a rigid insulation composed of sealed glass cells. Each cell is an insulating air space. Foamglass is all glass and is completely inorganic. The insulation on refrigerant lines, ducts, and piping is covered and banded by stainless steel jacketing to minimize or eliminate the conditions whereby the insulation could crumble. The insulation on the containment vessel is covered by a stainless steel sheath. This insulation is also located in areas least affected by postulated pipe breaks (i.e., in upper regions of the containment and outside the crane wall). In addition to it being completely encased AS WELL AS BEING LOCATED in areas protected from the effects of pipe breaks, this insulation will float and cannot enter the sump because of a 13.2 foot minimum water level which exists over the containment floor before recirculation begins.

Rubatex Insulation

Rubatex Insulation is a flexible closed-cell rubber type insulation. This insulation is located on portions of the ice condenser system where it is least affected by postulated pipe breaks (i.e., upper plenum area of the ice condenser). This insulation is not expected to suffer damage from any primary system pipe break; however, it should be noted that the insulation will float and could not enter the sump because of a 13.2 foot minimum water level which exists over the containment floor before recirculation begins.

Fiberglass Insulation

Fiberglass insulation is a glass fiber preformed pipe insulation encased in a vapor barrier jacket for the air-handling units. For the ice condenser crane wall insulation, end wall insulation, and for sealing the joints in the ice condenser wall, the glass fiber is in blanket form enclosed in polyethylene bags and covered by metal panels. The insulation in all cases is behind metal (i.e., inside housing of air-handling unit or under metal wall panels) to protect and assure it does not have a pathway to the sump.

Polyurethane and Urethane Foam Insulation

Polyurethane and urethane foam insulation are closed cell urethane resin foams. The polyurethane foam between the air ducts and the containment vessel does not have a pathway to the sump. The polyurethane foam insulating the top deck of the ice condenser is a blanket between stainless steel sheaths. The assembly rests on floor grating and is hinged at the crane wall to form doors that open upon a LOCA. This assembly maintained its integrity when tested under blowdown conditions that exceeded the worst LOCA. The urethane foam insulating the ice condenser inlet doors is completely enclosed. (Refer to FSAR Figures 6.5-20 and 6.5-23.) These doors have been tested rigorously.

Mineral Wool Insulation

Mineral wool insulation is a refractory fiber block insulation laminated and bonded by high-temperature binders. The insulation is between the process piping and the penetration sleeve and would not be subject to direct sprays and water from pipe breaks.

E. PIPE BREAK LOCATIONS

Refer to the FSAR for a list of the pipe break locations for high-energy piping inside the primary containment.

F. FSAR REFERENCES ON PERTINENT INSULATION QUESTIONS

None were submitted by TVA.

G. PRELIMINARY INSULATION DEBRIS HAZARD ANALYSIS

Figure J-1 is a simplified sketch of Sequoyah Nuclear Unit 2 primary containment. The reactor vessel, steam generators, and associated piping are all located within the crane wall. The containment emergency sump is located inside the shield wall near loop 4 as shown in Figure J-2.

A pipe break in loop 4 of the reactor coolant system could cause a substantial amount of reflective insulation to be blown in the vicinity of the containment sump. Figures J- 3 and 4 show the gratings protecting the containment sump. The grating is provided to protect the sump against the effects of insulation debris. According to TVA, both the grating at elevation 688.5 and over the sump are designed to withstand the effects of the jet from the pipe break and insulation panels hurtling into the grating and sump inlet structure. According to TVA, in the most conservative hypothetical case, the largest flat surface area of insulation covering an elbow together with the largest parting surface can be assumed to be against the sump screen. The total area blocked by these two sections of minor insulation would be 8.88 square feet of the sump screen area of 46.2 square feet. TVA Report No. WM28-1-45-102, "Model Study of the Sequoyah RHR Sump," shows that a 50-percent blockage of the screen area has a negligible effect on the sump operation.

The Mirror insulation used inside the shield wall is made entirely of stainless steel sheet material and does not contain any other materials. Mirror insulation will not segment or break up into small particles. The sections will sink to the bottom and remain stationary.

Since the containment sump is located inside the shield wall, insulation debris from outside the shield wall should not pose a problem. The Foamglass, Rubatex, fiberglass, polyurethane, and urethane foam insulation are located in areas that do not contain high-energy piping.

H. REFERENCES

1. Sequoyah 2, Final Safety Analysis Report
   Tennessee Valley Authority, Chattanooga, Tennessee.

2. Tennessee Valley Authority. "Model Study of the Sequoyah
   RHR Sumps" TVA Report NO. WM28-1-45-102, July 21, 1980.

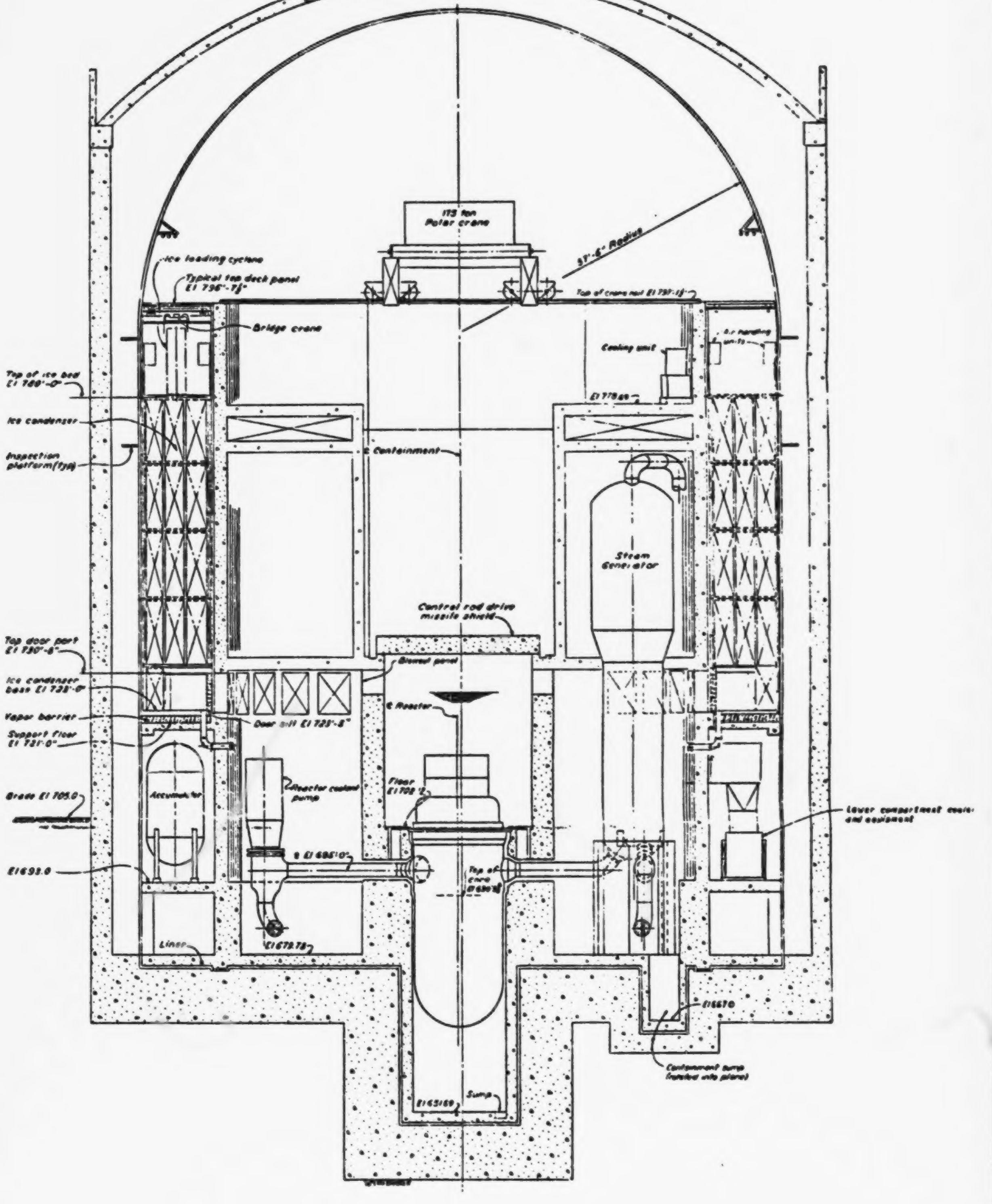
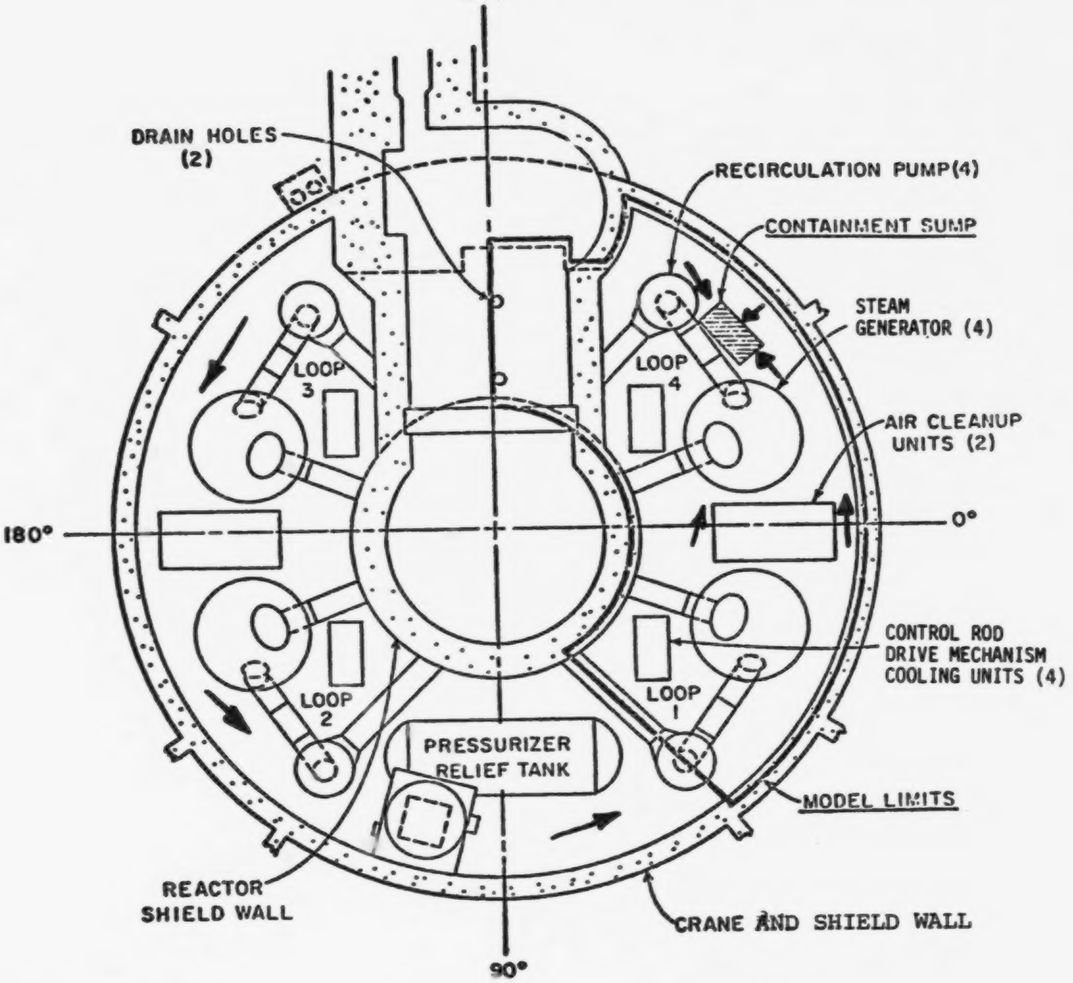

175 ton Polar crane
37'-6" Radius
Ice loading cyclone
Typical top deck panel El 796'-7½"
Top of crane rail El 791'-1½"
Bridge crane
Cooling unit
Air handling units
Top of ice bed El 788'-0"
El 778.60
Ice condenser
Inspection platform(typ)
℄ Containment
Steam Generator
Control rod drive missile shield
Top door port El 730'-6"
Blowout panel
Ice condenser base El 723'-0"
℄ Reactor
Vapor barrier
Door sill El 723'-3"
Support floor El 721'-0"
Reactor coolant pump
Floor El 702'2
Accumulator
Grade El 705.0
Lower compartment cooler and equipment
℄ El 695'0"
El 693.0
Top of core El 680'8
El 679.78
Liner
El 667.0
Containment sump (rotated into plane)
El 651.69
Sump

FIGURE J-1. Primary containment, Sequoyah Unit 2


270°
DRAIN HOLES (2)
RECIRCULATION PUMP(4)
CONTAINMENT SUMP
STEAM GENERATOR (4)
LOOP 3
LOOP 4
AIR CLEANUP UNITS (2)
180°
0°
CONTROL ROD DRIVE MECHANISM COOLING UNITS (4)
LOOP 2
LOOP 1
PRESSURIZER RELIEF TANK
MODEL LIMITS
REACTOR SHIELD WALL
CRANE AND SHIELD WALL
90°

NOTE: Arrows show pathways for insulation debris to reach sump.

TYPE OF INSULATION INSIDE PRIMARY COOLANT SYSTEM SHIELD WALL	APPROXIMATE QUANTITY FT^2
Reflective Metallic	18,500

Figure J-2. Primary containment plan view, Sequoyah Unit 2

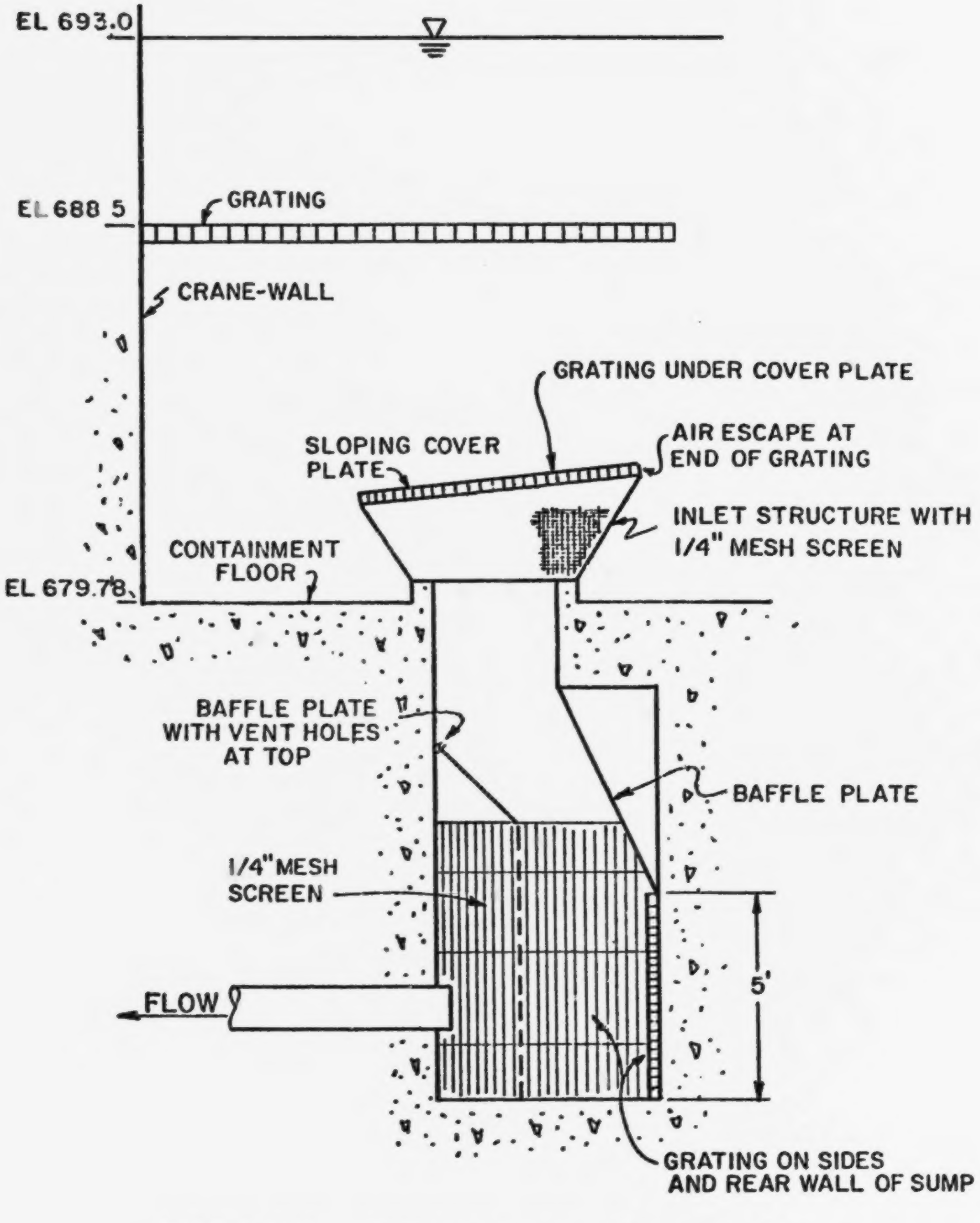

EL 693.0
EL 688 5
GRATING
CRANE-WALL
GRATING UNDER COVER PLATE
SLOPING COVER PLATE
AIR ESCAPE AT END OF GRATING
INLET STRUCTURE WITH 1/4" MESH SCREEN
CONTAINMENT FLOOR
EL 679.78
BAFFLE PLATE WITH VENT HOLES AT TOP
BAFFLE PLATE
1/4" MESH SCREEN
5'
FLOW
GRATING ON SIDES AND REAR WALL OF SUMP

FIGURE J-3. Emergency sump, Sequoyah Unit 2

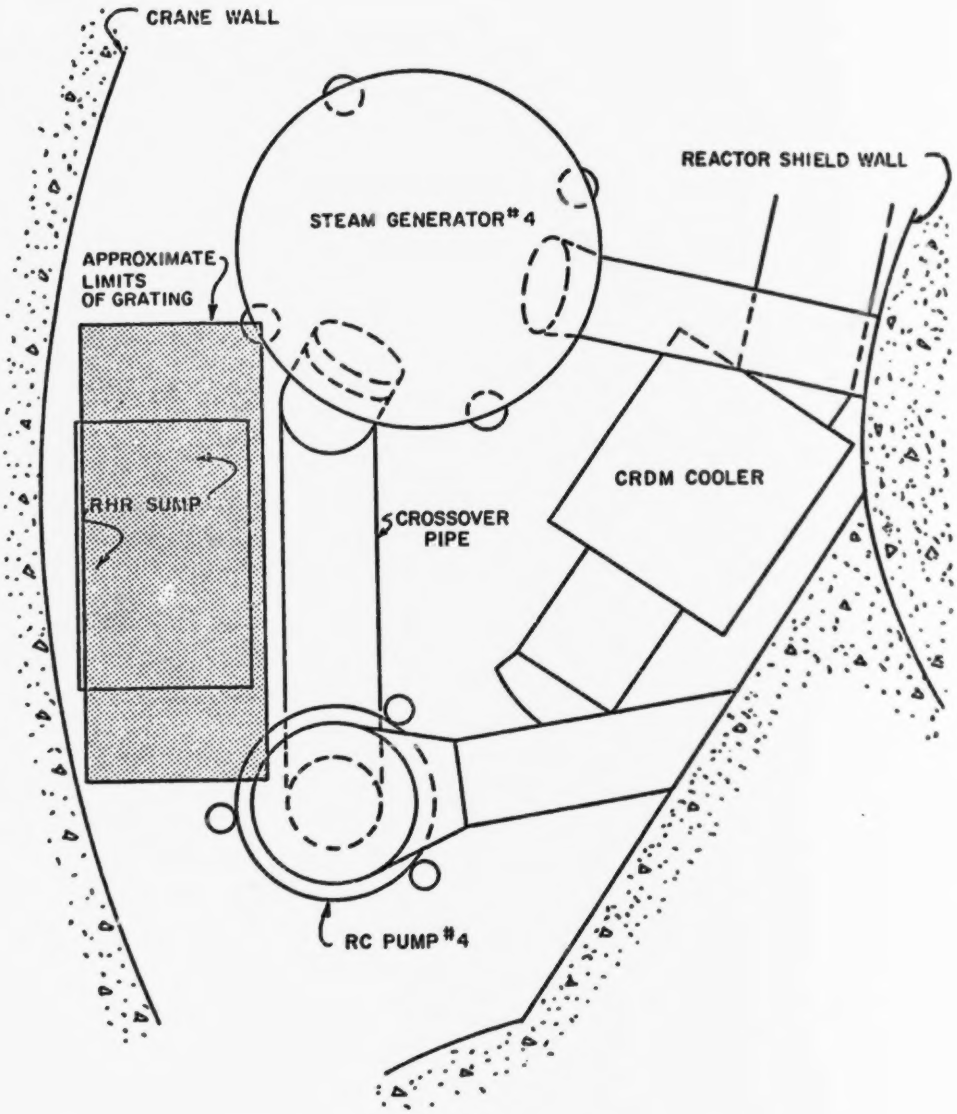

CRANE WALL
REACTOR SHIELD WALL
STEAM GENERATOR #4
APPROXIMATE LIMITS OF GRATING
CRDM COOLER
RHR SUMP
CROSSOVER PIPE
RC PUMP #4

FIGURE J-4. Plan view of emergency sump, Sequoyah Unit 2

APPENDIX K

MCGUIRE UNITS 1 AND 2:

PRELIMINARY ASSESSMENT OF INSULATION DEBRIS GENERATED DURING A PIPE BREAK EVENT

A. INTRODUCTION

This report documents the information sent to Burns and Roe by Duke Power Company for the survey of thermal insulation inside the primary containment of the 1180 MWe, Westinghouse PWR, McGuire Nuclear Station Unit 1, scheduled for commercial operation in 1981, and for Unit 2, scheduled for commercial operation in 1983.

The information gathered depicts the following:

1. The arrangement of all piping within the primary containment including high energy fluid piping
2. The location and configuration of the emergency intake sump for emergency core cooling; and the communicating paths by which debris generated by a major pipe break could reach the recirculation intake sump
3. Details of the insulation that could be dislodged and become a source of debris as the result of a major break

According to Duke Power Company, reflective metallic insulation, manufactured and installed as shown on the drawings provided, is used exclusively within the shielded crane wall area for both equipment and piping. Outside of the shield wall area, only the refrigerant piping for the ice condenser system contains insulation other than reflective metallic insulation. This refrigerant piping is covered with a urethane pipe covering 1 inch in thickness for piping 6 inches and smaller and 1-1/2 inches in thickness for piping above 6 inches.

B. LISTING OF INPUT DRAWINGS AND OTHER DOCUMENTS

This section provides a listing of drawings showing details of the containment and reactor building, emergency sump details, flow diagrams for insulated systems inside the containment, piping layout drawings (marked to show location of insulation). Also included is a list of McGuire FSAR references regarding the containment emergency sump, insulation specifications, a table of weights for reflective insulation, and a Diamond Power Specialty Company report entitled, "Response of Mirror Insulation to LOCA Conditions."[1]

Sufficient information is included herein for an organization to conduct an independent debris analysis.

1. Documentation

a. Specification MCS-1206.10	Conventional Heat Insulation
b. Specification MSC-1206.13	Reactor Vessel Reflective Insulation
c. Specification MCS-1206.14	Reactor Building and Piping Reflective Insulation

d. List of McGuire Containment Sump FSAR References
e. Table of Weights for Reflective Insulation
f. Diamond Power Specialty Company report entitled, "Response of Mirror Insulation to LOCA Conditions," dated May 30, 1978

2. Drawings

a. General Arrangement-Containment and Reactor Building (Information Only-Not As-Builts)

MCC-1041-1	Unit 1 Plan at El. 696'+ 11"
MCC-1041-2	Unit 1 Plan at El. 725'- 0"
MCC-1041-3	Unit 1 Plan at El. 738'- 3"
MCC-1041-4	Unit 1 Plan at El. 767'-10-3/4"
MCC-1041-5	Unit 1 Plan at El. 777'-10"
MCC-1041-6	Unit 1 Plan at El. 841'-10"
MCC-1041-7	Unit 1 Top Deck at El. 842'+ 5" and Laydown Space
MCC-1401-8	Containment and Reactor Building Section
MCC-1401-9	Containment and Reactor Building Section
MCC-1401-10	Auxiliary and Reactor Building Refueling Canal Layout, Longitudinal Section

b. Crane Wall Developed Elevation (Marked with Penetration Openings)

MCC-1051-1	Reactor Building - Unit 1 Crane Wall
MCC-1050-2	Developed Elevation Concrete El. 725'+0" through El. 841' + 10"

c. Emergency Sump Design Details

MC-1050-107	Reactor Building Units 1 and 2 Recirculation Intake Screen Miscellaneous Steel

d. Flow Diagrams for Insulated Systems Inside Containment

MC-1553-1.0	Reactor Coolant System (NC)
MC-1553-2.0	Reactor Coolant System (NC)
MC-1553-3.0	Reactor Coolant System (NC)
MC-1554-1.2	Chemical and Volume Control System (NV)
MC-1561-1.0	Residual Heat Removal System (ND)
MC-1562-1.0	Safety Injection System (NI)
MC-1562-2.0	Safety Injection System (NI)
MC-1562-2.1	Safety Injection System (NI)
MC-1562-3.0	Safety Injection System (NI)
MC-1580-1.0	Steam Generator Blowdown Recycle System (BB)
MC-1591-1.1	Feedwater System (CF)
MC-1592-1.0	Auxiliary Feedwater System (CA)
MC-1593-1.0	Main Steam System (SM)

	Main Steam Vent to Atmosphere (SV)
MC-1558-4.0	Ice Condenser Refrigeration System (NF)
MC-1558-5.0	Ice Condenser Refrigeration System (NF)
MC-1558-8.0	Ice Condenser Refrigeration System (NF)

e. Piping Layout Drawings (As-Built Drawings)

MC-1402-02.20-00	Steam Generator Blowdown System (BB) Plan Reactor Building
MC-1402-02.20-01	Steam Generator Blowdown System (BB) Sections Reactor Building
MC-1403-01.20-00	CA, BW, YA, TE System Plan Reactor Building
MC-1403-01.20-01	CA, BW, YA, TE System Sections Reactor Building
MC-1403-01.20-02	CA, BW, YA, TE System Sections Reactor Building
MC-1403-06.20-00	Feedwater System (CF) Plan Reactor Building
MC-1403-06.20-01	Feedwater System (CF) Section Reactor Building
MC-1414-03.20-00	NC System Plan Reactor Building
MC-1414-03.20-01	NC System Plan Reactor Building
MC-1414-03.20-02	NC System Section Reactor Building
MC-1414-03.20-03	NC System Section Reactor Building
MC-1414-03.20-04	NC System Pressurizer Plans and Sections Reactor Building
MC-1414-03.20-05	NC System RTD Loops Plan Reactor Building
MC-1414-04.20-00	ND System Plan Reactor Building
MC-1414-04.20-01	ND System Section Reactor Building
MC-1414-09.21-00	NI System Plan Reactor Building
MC-1414-09.22-00	NI System Plan Reactor Building
MC-1414-09.22-01	NI System Sections Reactor Building
MC-1414-22.20-00	NV System Plan El. 725' through 738'-3" Reactor Building
MC-1414-22.20-01	NV System Sections Reactor Building
MC-1414-22.20-02	NV System Enlarged Plan Reactor Building
MC-1414-22.22-00	NV System Plan El. 738'-3" through 762'-6" Reactor Building
MC-1414-22.22-02	NV System Sections Reactor Building
MC-1419-13.20-00	SM System Plan Reactor Building
MC-1419-13.20-01	SM System Sections Reactor Building
MC-1414-06.21-00	NF System El. 766' 2-1/2" to El. 800'-0" Plan Reactor Building
MC-1414-06.21-01	NF System, Part Plan and Sections
MC-1414-06.22-00	NF System, Plan Above 800' - 0" Reactor Building
MC-1414-06.22-01	NF System, Part Plan and Section Reactor Building

f. Reflective Metallic Insulation Drawings

Equipment	Insulation Thickness	Drawing Number
Reactor Vessel	3-1/2"	MCM-1206.13-1 thru 7
Steam Generators	3-2/3"	MCM-1206.13-8 thru 16 and 32
Coolant Pumps	4-1/2"	MCM-1206.13-18 thru 21
Pressurizer	5-1/2"	MCM-1206.13-22 thru 27
Regenerative HX	2-1/3"	MC-1206.13-44

Piping

System	Pipeline	Insulation Thickness	Drawing Number
NI	1-1/2" Boron Inj.	2-1/3"	MCM-1206.13-37
	6" Safety Inj.	2-2/3"	MCM-1206.13-31 Sh 1-4
	10" Accumulator Inj.	2-2/3"	MCM-1206.13-30 Sh 1-4
NC	14" Press. Surge Line	3-1/3"	MCM-1206.13-34
	34" Reactor Coolant Hot Leg	3-1/3"	MCM-1206.13-28 Sh 1-4
	32" R.C. Cold Leg	3-1/3"	MCM-1206.13-29 Sh 1-4
	R.C. Crossover Leg	3-1/3"	MCM-1206.13-33 Sh 1-4
	4" & 6" Press. Spray Line	2-2/3"	MCM-1206.13-38 Sh 1-4
	1", 2" & 3" R.T.D. Lines	2-1/3"	MCM-1206.13-42 Sh 1-8
CA	4" & 6" Aux. Feedwater	2-1/3"	MCM-1206.13-45 Sh 1-8
CF	16", 18" & 24" Feedwater	2-1/3"	MCM-1206.13-39 Sh 1-4
ND	14" Residual Heat Removal	3-1/3"	MCM-1206.13-35 Sh 1-3
NV	3" CVCS Charging Line	2-1/3"	MCM-1206.13-40 Sh 1-7
	3" CVCS Letdown Line	2-1/3"	MCM-1206.13-41 Sh 1-3
	3" Letdown to Penetration	1/3"	MCM-1206.13-46 Sh 1-5
	2" Aux. Press. Spray Line	2"	MCM-1206.13-47
BB	1" & 2" S.G. Blowdown Lp4	2-1/3"	MCM-1206.13-48 Sh 1-4

	1" & 2" S.G. Blowdown Lp3	2-1/3"	MCM-1206.13-49 Sh 1-2
	1" & 2" S.G. Blowdown Lp2	2-1/3"	MCM-1206.13-50 Sh 1-4
	1" & 2" S.G. Blowdown Lp1	2-1/3"	MCM-1206.13-51 Sh 1-4
NC	3" & 6" Press. Relief Line	3"	MCM-1206.13-52 Sh 1-2
SM	42" Main Steam	3-1/3"	MCM-1206.13-43 Sh 1-4

C. LISTING OF PIPING SYSTEMS INSIDE CONTAINMENT CONTAINING INSULATION

This section provides a list of the systems inside primary containment containing insulation. The list includes the system, nominal pipe sizes inside containment, and the type of insulation used for each system.

System	Nominal Pipe Sizes (inches)	Type of Insulation
Boron Injection	1-1/2	Reflective metallic
Safety Injection	6	Reflective metallic
Accumulator Injection	10	Reflective metallic
Pressurizer Surge Line	3-1/3	Reflective metallic
Reactor Coolant	34, 32	Reflective metallic
Pressurizer Spray Line	6, 4, 2	Reflective metallic
RTD Lines	3, 2, 1	Reflective metallic
Auxiliary Feedwater	6, 4	Reflective metallic
Chemical Volume Control	3	Reflective metallic
Steam Generator Blowdown	2, 1	Reflective metallic
Pressurizer Relief Lines	6, 3	Reflective metallic
Main Steam	42	Reflective metallic
Refrigerant Piping for Ice Basket and Glycol Piping	5, 4, 2, 1-1/2, 1/2	Urethane pipe covering with vapor barrier

D. TYPICAL INSULATION DETAILS

Reflective metallic insulation is used for all piping and equipment inside the reactor containment with the exception of the refrigerant piping used for the ice condenser and portions of the ice condenser. The insulation utilized for the piping and ice condenser is antisweat urethane pipe covering with a vapor barrier.

The reflective insulation is described in Appendix A of this report. The insulation company is Mirror Insulation, a unit of Diamond Power Specialty Company.

The insulation panels for piping and equipment are 26-gauge stainless steel outer sheets for horizontal piping and 28-gauge outer sheets for vertical piping with inner radiation sheets of 4-mils stainless steel. Similarly, the insulation panels for the reactor vessel are stainless steel with inner radiation sheets of 4-mils thickness.

A Diamond Power Specialty Company report entitled "Response of Mirror Insulation to LOCA Conditions" has been included in the data package. The following results are stated by Diamond Power:

1. The differential pressure necessary to collapse all-metal reflective insulation against piping or equipment will be less than 2 psi.

2. The internal differential pressure required to separate units of insulation for the vessel insulation, which is a worst case, is 2.4 psi.

3. A velocity of water of over 1.9 ft/sec is required to transport a panel whose face is normal to the direction of flow. At other orientations, higher velocities will, of course, be required.

Based on the these results, Diamond Power concludes that in a LOCA condition all-metal reflective insulation will:

- Be instantly crushed in the vicinity of pipe breaks due to the external differential pressure

- Insulation in line with the jet from a pipe break will be blown off the pipe or vessel due to the internal differential pressure that would develop

- Insulation panels only in the immediate vicinity of a pipe break will be transported by the steam or air flow

- Insulation assemblies falling into containment will sink rather than be transported by the low circulation velocity in the sump

Urethane is a rigid cellular foam plastic which has a high-strength to low-density ratio. It has a tensile strength of ~ 30 psi and a shear strength of ~ 20 psi. It comes in approximately four foot lengths and has excellent abuse and damage resistance. It has a low vapor permeability and a high resistance to water absorption. Its density is approximately 2.0 lbs/ft^3.

E. PIPE BREAK LOCATIONS

Refer to the FSAR[2] for a list of the pipe break locations for high energy piping inside the primary containment.

F. FSAR REFERENCES ON PERTINENT INSULATION QUESTIONS

The following FSAR references are pertinent:

1. Containment Sump Design
   Chapter 6.0, Section 6.5.2, Pages 6.5-5, Table 6.5.2-3

   NRC Questions on Sump Design

Q042.27	Pages 6.5-5 and 6.5-5a
Q042.43	Page 6.5-5a
Q042.58	Page 6.5-5a
Q042.51	Page 6.5-5a

2. Containment Sump Recirculation Test Chapter 6.0, Section 6.3.4, Page 6.3-26a

   NRC Question on Testing

Q212.56	Page 6.3-26a

3. RHR Available NPSH
   Chapter 6.0, Section 6.3.2.14, Pages 6.3-19 and 6.3-19a

Q042.50	Pages 6.3 and 6.3-19a
Q212.51	Pages 6.3 and 6.3-19a
Q042.26	Pages 6.3 and 6.3-19a

4. Containment Spray Pump Available NPSH
   Chapter 6.0, Section 6.5.2, Pages 6.5-3a and 6.5-4

   NRC Questions and Available NPSH

Q042.26	Pages 6.5-3a and 6.5-4
Q042.50	Pages 6.5-3a and 6.5-4
Q042.51	Pages 6.5-3a and 6.5-4

G. PRELIMINARY INSULATION DEBRIS HAZARD ANALYSIS

Figures K-1 and K-2 are simplified sketches of McGuire Unit 1 primary containment. The reactor vessel, steam generators, pressurizer, and associated piping are all located within the crane wall. The emergency intake sump is located outside the crane wall on the basement floor at elevation 725'. Figure K-3 shows the details of the emergency intake sump. The penetration openings in the crane shield wall are shown in Figure K-4 and in greater detail in Figure K-5. The largest opening is 8 inches in diameter.

The penetration openings are provided in the crane shield wall to allow drainage of water to the emergency intake sump for the recirculation mode in the event of a pipe break in the reactor coolant system.

Insulation debris resulting from a pipe break within the crane shield wall would have to float through a penetration opening in the shield wall and migrate towards the emergency intake sump to block the sump screen. All the insulation for the piping and equipment inside the crane shield wall is reflective metallic insulation. This insulation will sink to the floor of the containment if blown off the piping. If a small amount of insulation floated through an opening, this insulation would sink to the floor outside the shielded area and not migrate to the emergency intake sump. A high velocity of over 1.9 ft/sec is required to transport a panel whose face is normal to the direction of flow. The velocity outside the crane wall would be a small fraction of that required to propel the panel.

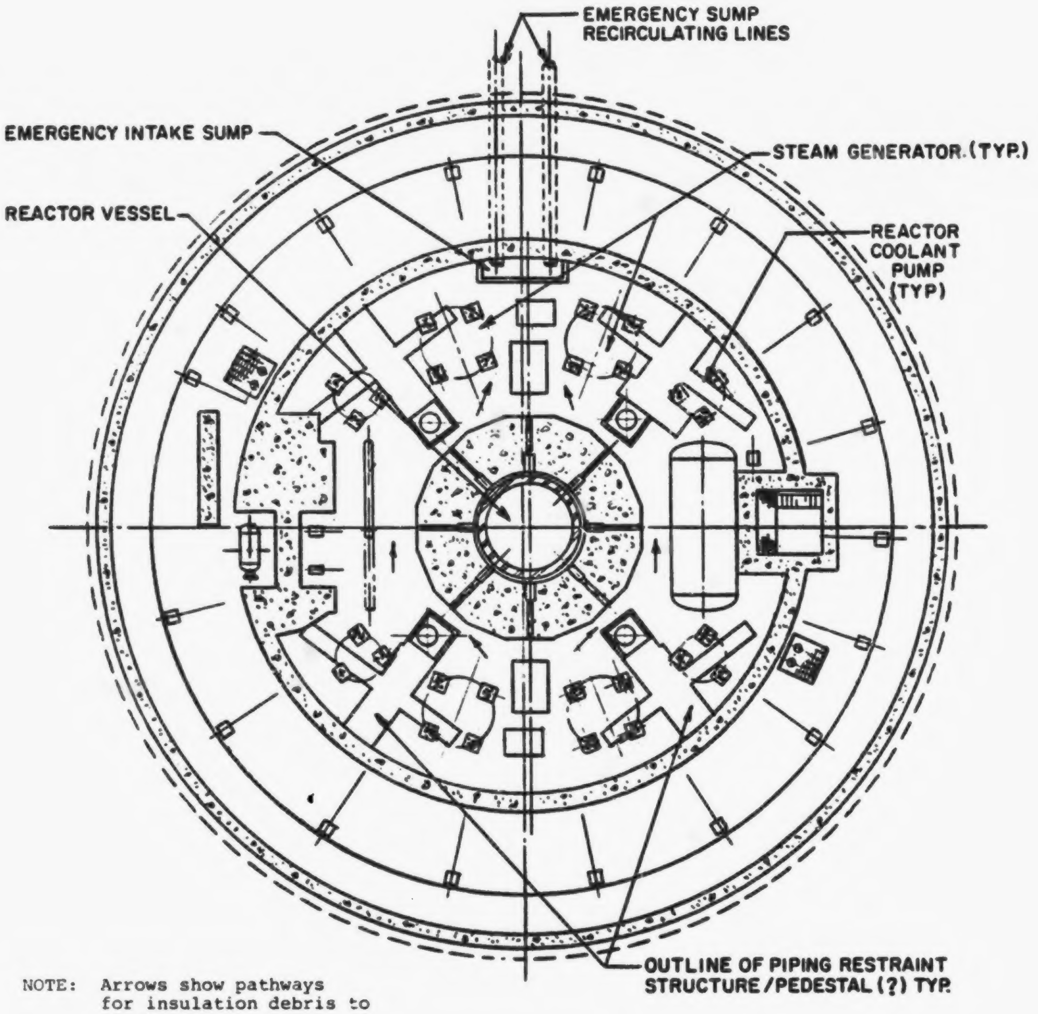
Outside the crane shield wall, there is not any reflective insulated piping in the vicinity of the emergency intake sump. The refrigerant piping insulated with urethane is located above the floor elevation 766'-8-1/2". Since there is no high-energy piping located in this area, this insulation would not be affected. It is doubtful that this insulation could pose a problem to the emergency sump during a pipe break event.

Insulation debris from piping systems as a result of the pipe break have a very small probability of reaching the emergency intake sump. Inspection of antisweat urethane insulation used in the reactor building should be done on a periodic basis to insure that it is secured properly and does not pose a problem when pipe breaks occur resulting in high humidity conditions in the containment.

H. REFERENCES

1. Diamond Power Specialty Company. "Response of Mirror Insulation to LOCA Conditions," Diamond Power Specialty Company Report, May 30, 1978.

2. McGuire 1, Final Safety Analysis Report, Duke Power Company, Charlotte, North Carolina.


EMERGENCY SUMP RECIRCULATING LINES
EMERGENCY INTAKE SUMP
STEAM GENERATOR (TYP.)
REACTOR VESSEL
REACTOR COOLANT PUMP (TYP)
OUTLINE OF PIPING RESTRAINT STRUCTURE/PEDESTAL (?) TYP.

NOTE: Arrows show pathways for insulation debris to reach sump.

TYPE OF INSULATION INSIDE PRIMARY COOLANT SYSTEM SHIELD WALL	APPROXIMATE QUANTITY Ft^2
Reflective Metallic	18,000

Figure K-1. Reactor containment plan view, McGuire Units 1&2

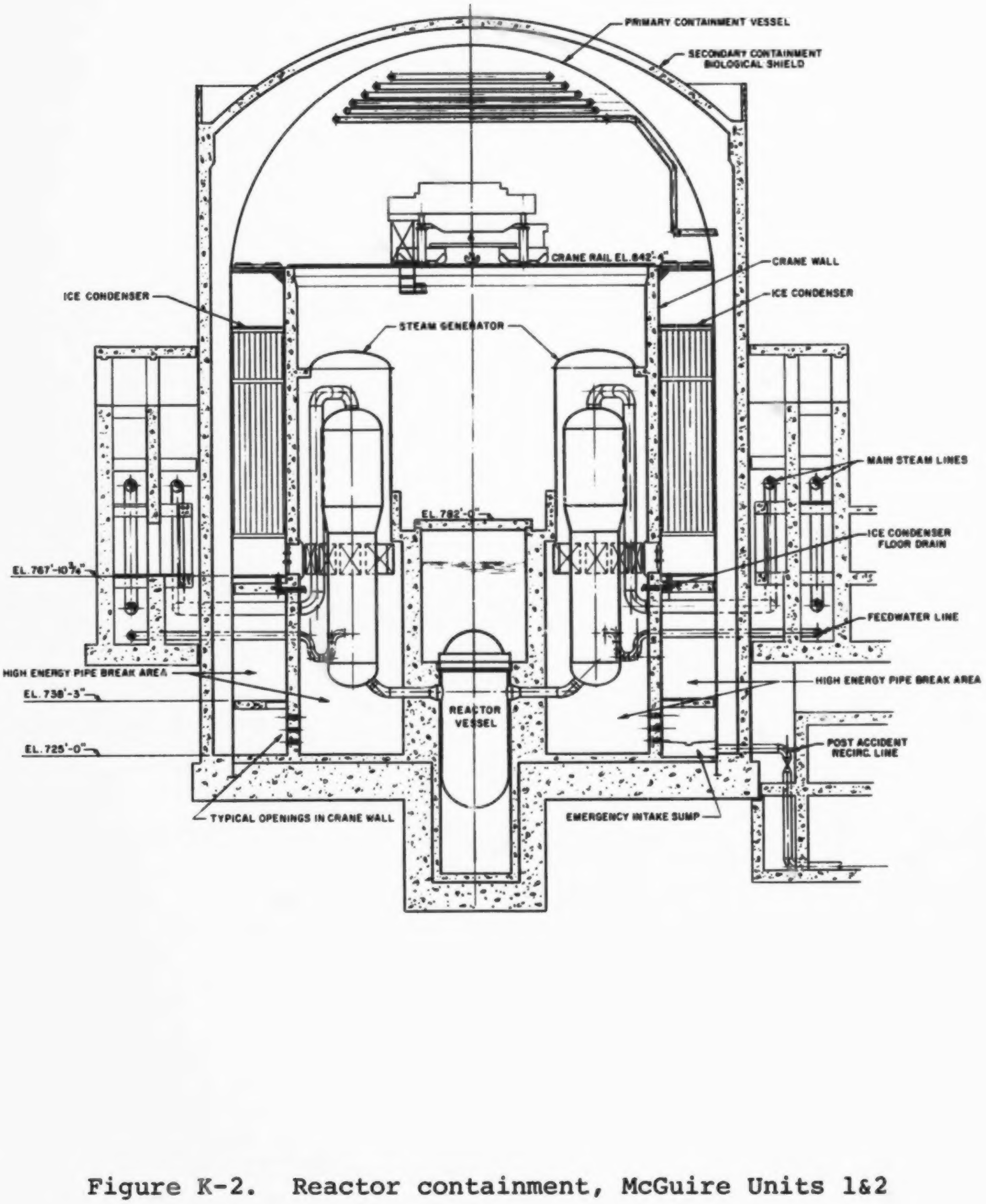
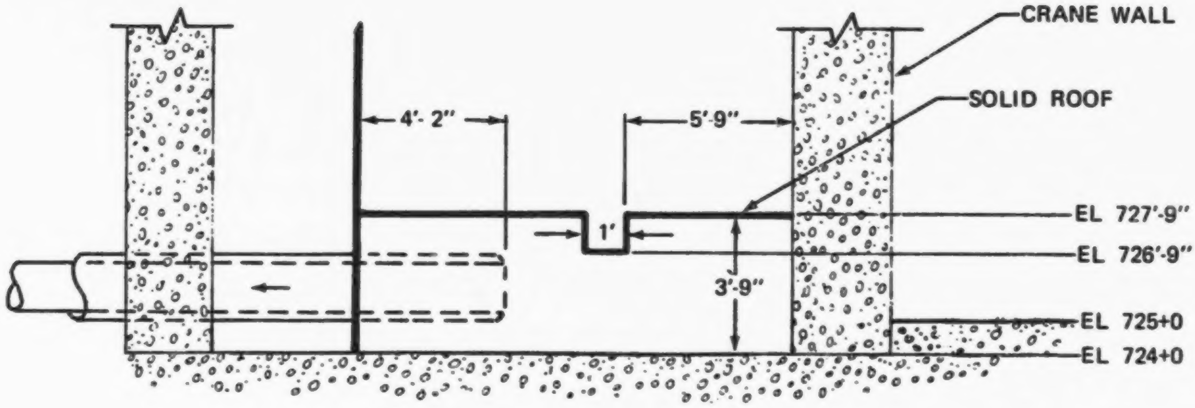
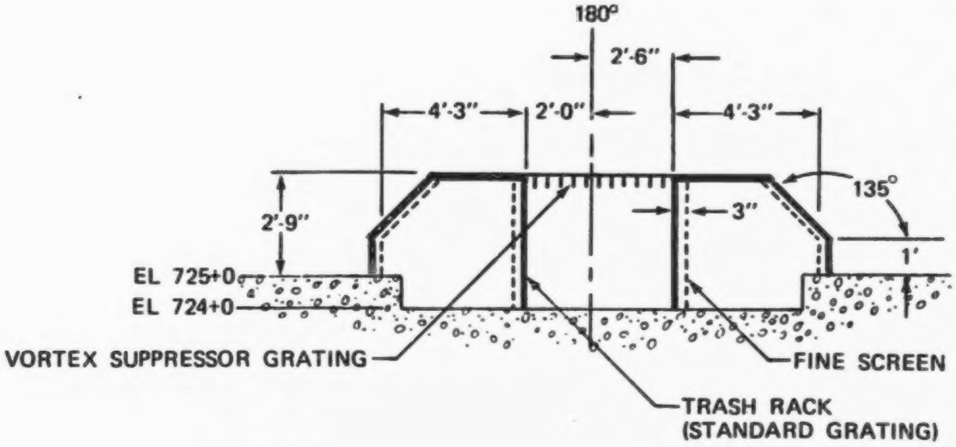

PRIMARY CONTAINMENT VESSEL
SECONDARY CONTAINMENT BIOLOGICAL SHIELD
CRANE RAIL EL. 842'-4"
CRANE WALL
ICE CONDENSER
ICE CONDENSER
STEAM GENERATOR
MAIN STEAM LINES
EL. 782'-0"
ICE CONDENSER FLOOR DRAIN
EL. 767'-10 3/4"
FEEDWATER LINE
HIGH ENERGY PIPE BREAK AREA
HIGH ENERGY PIPE BREAK AREA
EL. 738'-3"
REACTOR VESSEL
EL. 725'-0"
POST ACCIDENT RECIRC. LINE
TYPICAL OPENINGS IN CRANE WALL
EMERGENCY INTAKE SUMP

Figure K-2. Reactor containment, McGuire Units 1&2

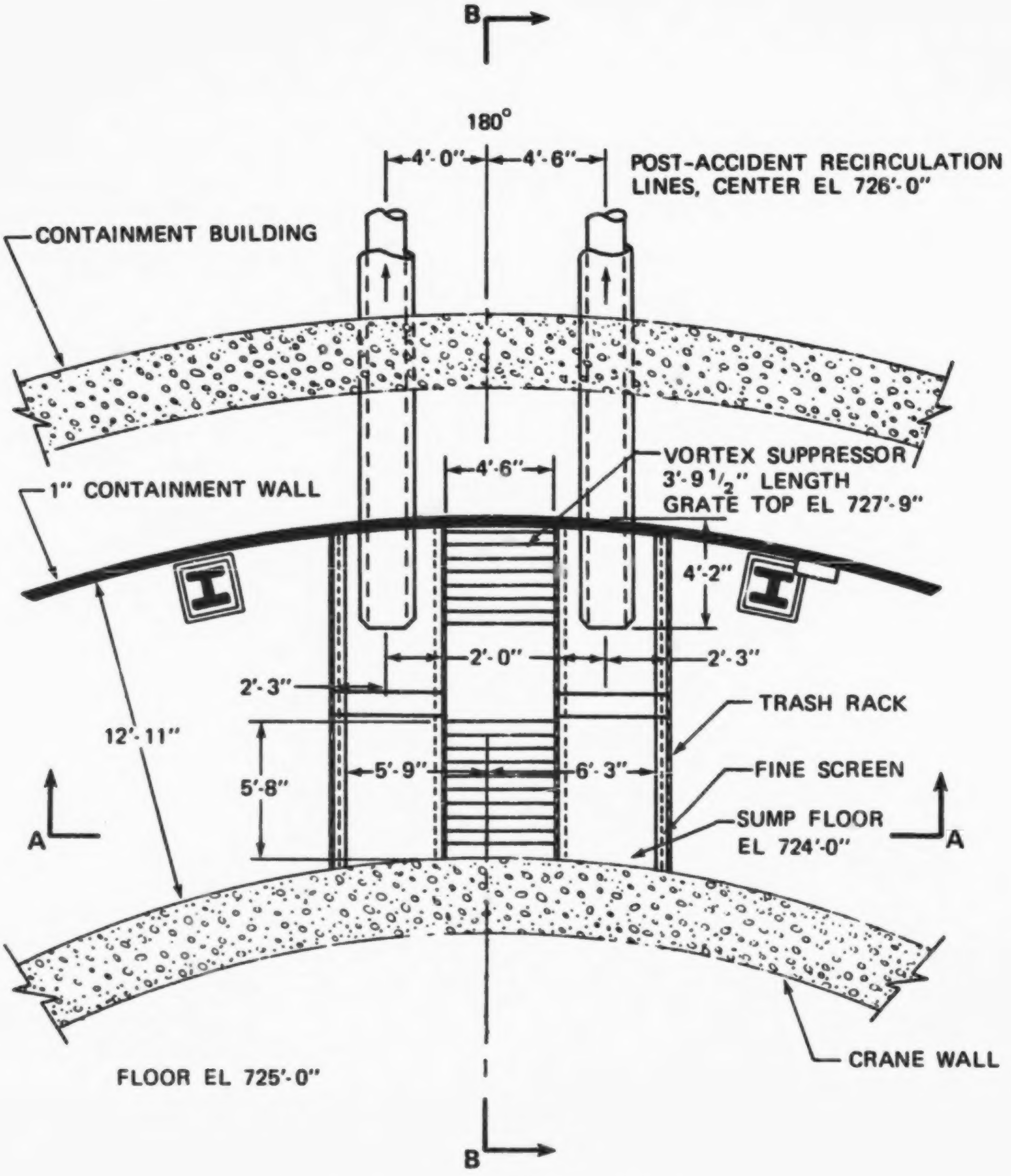

CRANE WALL
SOLID ROOF
4'- 2"
5'-9"
1'
3'-9"
EL 727'-9"
EL 726'-9"
EL 725+0
EL 724+0

SECTION B-B


180°
2'-6"
4'-3"
2'-0"
4'-3"
2'-9"
3"
135°
1'
EL 725+0
EL 724+0
VORTEX SUPPRESSOR GRATING
FINE SCREEN
TRASH RACK
(STANDARD GRATING)

SECTION A-A

Figure K-3. The revised design of containment sump, McGuire Unit 1


B
180°
4'-0"
4'-6"
POST-ACCIDENT RECIRCULATION LINES, CENTER EL 726'-0"
CONTAINMENT BUILDING
4'-6"
VORTEX SUPPRESSOR 3'-9 1/2" LENGTH GRATE TOP EL 727'-9"
1" CONTAINMENT WALL
4'-2"
2'-0"
2'-3"
2'-3"
TRASH RACK
12'-11"
5'-9"
6'-3"
FINE SCREEN
5'-8"
SUMP FLOOR EL 724'-0"
A
A
CRANE WALL
FLOOR EL 725'-0"
B

RECOMMENDED PROTOTYPE SCREENS AND GRATINGS

FINE SCREEN: 0.063" DIAMETER WIRES
3-3/4" MESH

TRASH RACK: STANDARD GRATING
1"x 3/16" BEARING
BARS AT 1" CLEAR SPACING

VORTEX SUPPRESSOR: TWO STANDARD
GRATING 1 1/2" x 1/8"
BEARING BARS ONE ABOVE
THE OTHER WITH BARS
RUNNING PERPENDICULAR
(TENTATIVE)

Figure K-4. Revised design of containment recirculation sump, McGuire Unit 1

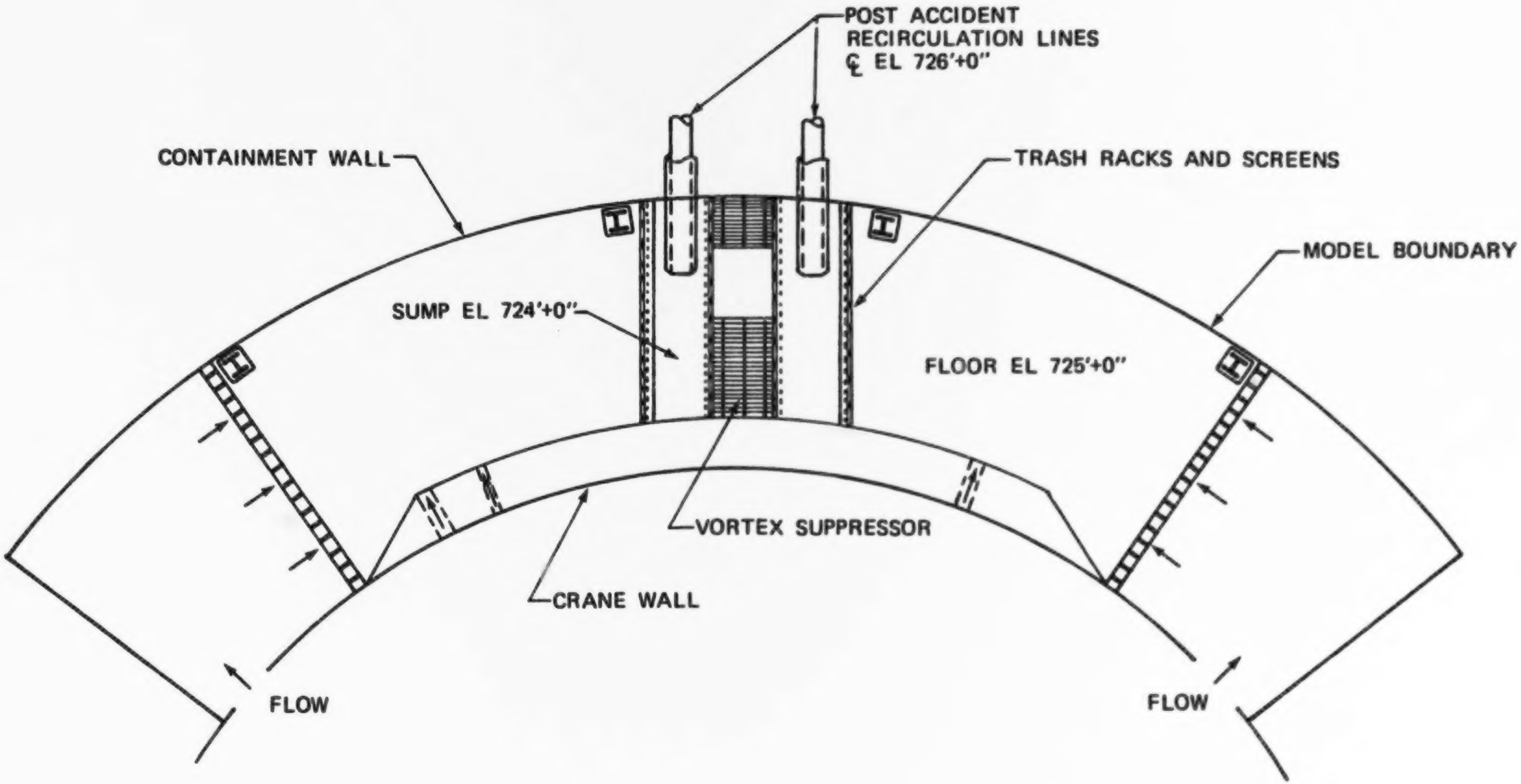

POST ACCIDENT
RECIRCULATION LINES
℄ EL 726'+0"
CONTAINMENT WALL
TRASH RACKS AND SCREENS
MODEL BOUNDARY
SUMP EL 724'+0"
FLOOR EL 725'+0"
VORTEX SUPPRESSOR
CRANE WALL
FLOW
FLOW

Figure K-5. Modeled portion of containment revised design sump, McGuire Unit 1

APPENDIX L

COOPER STATION:

PRELIMINARY ASSESSMENT OF INSULATION DEBRIS GENERATED DURING A PIPE BREAK EVENT

A. INTRODUCTION

This report documents the information gathered by Burns and Roe's survey of thermal insulation inside the primary containment of the 778 MWe, BWR/4, Mark I containment vessel of the Cooper Nuclear Station which went into commercial operation in 1974.

The information gathered covers the following:

1. The arrangement of all insulated piping within the primary containment.
2. The location and configuration of the intakes for the engineered core cooling systems.
3. The communicating path by which debris generated by a pipe break in containment can reach the pump suction inlet of the pumps for the residual heat removal, core spray, reactor core injection cooling, and high-pressure core injection cooling system.
4. Details of the insulation that could be dislodged and become a source of debris as a result of the break.

According to information provided by Nebraska Public Power, insulation of piping systems in the drywell includes the following:

Thermal insulation consists of two types - removable and permanent. Removable insulation is installed on all pipes 2-1/2 inches and larger requiring inservice inspection. This type of insulation is installed on the recirculation pump discharge, suction, and bypass lines, main steam, residual heat removal core spray, reactor water cleanup, and reactor feed piping. Permanent insulation is installed on these systems where pipes are 2 inches and smaller. Permanent insulation is also installed on the equipment, and floor drain sump pump discharge, standby liquid control system, process instrumentation and main steam relief valve discharge.

Antisweat insulation is installed in the control air and reactor building closed cooling water systems.

B. LISTING OF INPUT DRAWINGS AND OTHER DOCUMENTS

This section provides a tabulation of drawings showing details of the Mark I containment vessel, jet deflector platforms in containment, reactor building arrangements, and all piping inside containment. Also included are specifications for purchase of the reflecting metal insulation and insulation drawings. Sufficient information is included herein for an organization to conduct an independent debris analysis.

1. Documentation

Contract E71-9, "Piping, Ductwork and Equipment Installation"

2. Drawings

a. Structural Drawings

4227	Reactor Building Radial Beams
4240	Reactor Building Cross Section, Sh 1
4259	Containment Vessel, Sh 1
4260	Containment Vessel, Sh 2
4261	Containment Vessel, Sh 3
4262	Containment Vessel, Sh 4
4278	RB Radial Beams - Section and Details
4386	Energy Absorbing Panel Liner Location
4287	Modification to Torus

b. Mechanical Piping Drawings

M-2153	Reactor Building - Drywell Process Waste, Floor Drain, Equipment Drain, Miscellaneous Waste and Relief Valve Piping - Plans
M-2154	Reactor Building - Drywell Process Waste Floor Drain, Equipment Drains, Miscellaneous Waste and Relief Valve Piping - Sections and Details
M-2155	Reactor Building - Cond. Polishing, Fuel Pool Cooling, Main Steam, Reactor Water Cleanup, Reactor Feedwater, Service Water Standby Liquid Control Piping Plans at El. 859'-9" and 881'-9"
M-2156	Reactor Building - Cond. Polishing, Fuel Pool Cooling, Main Steam, Reactor Water Cleanup, Reactor Feedwater, Service Water, Standby Liquid Control Piping - Plans at El. 903'-6"
M-2157	Reactor Building - Cond. Polishing, Fuel Pool Cooling, Main Steam, Reactor Water Cleanup, Reactor Feedwater, Service Water, Standby Liquid Control Piping - Plan El. 931'-6"
M-2158	Reactor Building - Cond. Polishing, Fuel Pool Cooling, Main Steam, Reactor Water Cleanup, Reactor Feedwater, Service Water, Standby Liquid Control Piping - Plan El. 958'-3"
M-2159	Reactor Building - Cond. Polishing, Fuel Pool Cooling, Main Steam, Reactor Water Cleanup, Reactor Feedwater, Service Water, Standby Liquid Control Piping - Plan at El. 976'-0"

M-2160	Reactor Building - Cond. Polishing, Fuel Pool Cooling, Main Steam, Reactor Water Cleanup, Reactor Feedwater, Service Water, Standby Liquid Control Piping - Sections
M-2161	Reactor Building - Cond. Polishing, Fuel Pool Cooling, Main Steam, Reactor Water Cleanup, Reactor Feedwater, Service Water, Standby Liquid Control Piping - Sections
M-2162	Reactor Building - Cond. Polishing, Fuel Pool Cooling, Main Steam, Reactor Water Cleanup, Reactor Feedwater, Service Water, Standby Liquid Control Piping - Part Plan and Sections at El. 958'-3" and Miscellaneous Sections and Details
M-2165	Reactor Building - Reactor Core Isolation Coolant and High Pressure Coolant Injection Piping at El. 859'-9" and Sections
M-2166	Reactor Building - Control Rod Drive, Reactor Core Isolation Coolant, High Pressure Coolant Injection Piping at El. 881'-9"
M-2167	Reactor Building - Control Rod Drive, Reactor Core Isolation Coolant, High Pressure Coolant Injection Piping at El. 881'-9"
M-2168	Reactor Building - High Pressure Coolant Injection, Extraction, Main and Auxiliary Steam, Process Vent, Reactor Feedwater, Reactor Closed Cooling Piping Systems, Plan View and Sections - HPCI Room
M-2172	Reactor Building - Core Spray, Residual Heat Removal, Closed Cooling, Heating Steam and Heating Cond. Piping Plan El. 859'-9"
M-2173	Reactor Building - Core Spray, Residual Heat Removal, Closed Cooling, Heating Steam and Heating Cond. Piping - Plan El. 881'-9"
M-2174	Reactor Building - Core Spray, Residual Heat Removal, Closed Cooling, Heating Steam and Heating Cond. Piping - Plan El. 903'-6"
M-2175	Reactor Building - Core Spray, Residual Heat Removal, Closed Cooling, Heating Steam and Heating Cond. Piping - Plan El. 931'-6"
M-2176	Reactor Building - Core Spray, Residual Heat Removal, Closed Cooling, Heating Steam and Heating Cond. Piping - Plan El. 958'-3"

M-2177	Reactor Building - Core Spray, Residual Heat Removal, Closed Cooling, Heating Steam and Heating Cond. Piping - Plan - Part and Sections
M-2178	Reactor Building - Core Spray, Residual Heat Removal, Closed Cooling, Heating Steam and Heating Cond. Piping - Sections and Details
M-2179	Modification to Torus
M-2204	H&V - Drywell and Reactor Building Below Grade Plan
M-2205	H&V - Plan and Section - Drywell and Reactor Building - El. 903'-6"
M-2206	H&V - Plan and Section - Drywell and Reactor Building - El. 931'-6"
M-2207	H&V - Plan and Section - Drywell and Reactor Building - El. 958'-6"
M-2208	H&V - Plan and Section - Drywell and Reactor Building - El. 976'-0"
M-2209	H&V - Plan and Section - Drywell and Reactor Building - El. 1001'-0"
M-2210	H&V - Drywell and Reactor Building - Sections and Details
M-2212	H&V - Drywell and Reactor Building - Sections
M-2213	Reactor Building - Drywell - Plan and Sections - El. 888'-0" and 901'-3" - Air Conditioning
M-2281	Sump Disc. Inst. and Service Air Conditioning Supply, Fire Protection, Demineralized Water System Plan El. 881'-9"
M-2282	Sump Disc. Inst. and Service Air Conditioning Supply, Fire Protection and Demineralized Water System Plan at El. 903'-0"

c. Vendor Drawings

- Chicago Bridge and Iron (Contract E68-1)

Dwg. No.	Title
1	Ground Plan
2	Drywell Shell
5	Suppression Chamber Penetration Schedule and Orientation
8	Drywell Vent Insert Assembly and Jet Deflectors
50	Suppression Chamber General Arrangement and Field Assembly
51	Vent Header Assembly, Vent Line, Vacuum Breakers
53	Discharge Lines
56	Suppression Chamber Vent Header and Downcomer
69	Suppression Chamber ECCS Pump Suction Penetrations
67	Strainer Details

- Transco (Contract E71-9)

Dwg. No.	Title
RU-3376-1 through RU-3376-12	Installation Procedure Manual for Thermal Insulation of Recirculating Loop Piping
RU-3376-ST-4, -4A, -5, -6, -8, -10	
RU-3906-1 through RU-3906-8	Installation Procedure Manual for Main Steam Piping Insulation
RU-3958-1, -3	10" CS-1D Isometric
RU-3958-2, -4	10" CS-1D Panel Layout
RU-3958-5	6" CU-1S Isometric

RU-3958-6	6" CU-1S Panel Layout
RU-3958-7	10" MS-1 Isometric
RU-3958-8	10" MS-1 Panel Layout
RU-3958-9	3" MS-1 Isometric
RU-3958-10	3" MS-1 Panel Layout
RU-3958-11, -12	4", 12", 18" RF-1D Isometric
RU-3958-13, -15	12" RF-1D Panel Layout
RU-3958-14, -16	4", 12", 18" RF-1D Panel Layout
RU-3958-17	6" RH-1D Isometric
RU-3958-18	6" RH-1D Panel Layout
RU-3958-19	20" RH-1D and 20" RH-1S Isometric
RU-3958-20	20" RH-1D and 20" RH-1S Panel Layout
RU-3958-21	24" RH-1D 24" RH-1S
RU-3958-22, -23	24" RH-1D & 24" RH-1S Panel Layout

- General Electric

Dwg. No.	Title
729E427	Thermal Insulation Drywell Piping -Details
729E500	Equipment Handling Below PRV
729E662	Recirc. Loop Pipe Restraints (Add 803'-6" to all Dimensions)
729E734	Arrangement - Primary Containment
731E611	Primary Steam Piping

Documents	Title
21A1182	Standard Requirements for Reactor Vessel Insulation
21A1472	Thermal Insulation for Drywell Piping

C. LISTING OF PIPING SYSTEMS INSIDE CONTAINMENT CONTAINING INSULATION

This section provides a list of the piping systems inside primary containment containing insulation. The list includes the system, nominal pipe sizes inside containment, and the type of insulation used for each system.

System	Nominal Pipe Size (Inches)	Type of Insulation
Recirculation Pump	4,12,22,28	Reflective metallic and totally encapsulated
Main steam	3,10,24	Reflective metallic and totally encapsulated
Residual heat removal	6,20,24	Reflective metallic and totally encapsulated
Core spray pump	10	Reflective metallic and totally encapsulated
Reactor water cleanup pump	6	Reflective metallic and totally encapsulated
Reactor feed	4,12,18	Reflective metallic and totally encapsulated
Reactor building closed cooling water	1, 2-1/2,3,18	Antisweat
Control air	1	Antisweat

D. TYPICAL INSULATION DETAILS

Insulation for the Cooper Station was supplied under the following two contracts:

1. Contract E71-9 - Piping Ductwork and Equipment Insulation

    a. Reflective insulation used for drywell piping is nominally 3 to 4 feet long, 3 to 4 inches thick, and split into two sections with each section covering half of the pipe. These sections have 22-gauge type 304 stainless steel outer sheets which enclose layers of aluminum foil. Quick release fasteners hold the two sections together. The panels are provided with lifting handles. (See Figures L-1 and L-3.)

    Removable insulation is provided on piping systems subject to inservice inspection for sizes 2-1/2 inches and larger. Typical insulation details are shown on Transco drawings listed in Section B.2.c. above.

b. Antisweat insulation is specified as "Aerotube" polyurethane insulation, supplied by Johns-Manville with lagging manufactured by Zippertubing Co.

c. Nonreflective insulation consisting of encapsulated mineral wool is specified for carbon steel systems 8 inches and larger. Smaller carbon steel pipe sizes may use encapsulated mineral fiber or encapsulated inhibited calcium silicate. Stainless steel piping requires use of inhibited calcium silicate only, regardless of size. After insulation is secured, it is covered with an aluminum jacket 0.016 inch in thickness. This insulation is used primarily on piping systems that do not require inservice inspection.

2. Contract E66-31 - Nuclear Steam Supply System

a. Reactor Vessel Insulation

Details of insulation for the reactor vessel are specified in GE Document 21A1182, "Standard Requirements for Reactor Vessel Insulation," and GE Document 21A1182AN, "Reactor Vessel Insulation - Data Sheet."

b. Recirculation Loop Piping

Thermal insulation for recirculation loop piping is specified in GE Document 21A1251AK. The prefabricated pipe insulation consists of an aluminum cover sheet attached to a molded section of 3 inches unibestos insulation with quick-release fasteners.

c. Main Steam Piping

Thermal insulation for steam piping is specified in GE Document 21A1472AK. The general method of how insulation is to be fabricated for applications within the scope of these specifications is given in GE Dwg. 729E427, "Thermal Insulation Drywell Piping Details."

The insulation being furnished for the steam lines is encapsulated mineral wool. Panels are fabricated with an aluminum cover sheet and a stainless steel interior sheet.

E. PIPE BREAK LOCATIONS

Except for the recirculation piping, the FSAR Amendment 14 response to Question 5.16, Par. II, Pg. 5.16.3, states that, "There are no postulated pipe rupture locations."[1] This was concluded after an investigation of the critical piping systems "for location and magnitude maximum stress, as well as the stresses at terminal points, such as the RPV nozzle attachments and branch connections to major piping systems." The results of this investigation are shown on piping isometrics (FSAR, Fig. 5.16.1 through 5.16.11, inclusive), and a summary of stresses is shown in FSAR Table 5.16-1. For the recirculation system, pipe ruptures are postulated to occur anywhere and are assumed as either circumferential guillotine type breaks or longitudinal pipe splits.

F. FSAR REFERENCES ON PERTINENT INSULATION QUESTIONS

As of this date, questions have not been asked in connection with insulation migration.

G. PRELIMINARY INSULATION DEBRIS HAZARD ANALYSIS

Figure L-4 is a drawing of the Cooper primary containment vessel, showing the "light-bulb" shaped drywell and the "donut" shaped wetwell or torus. A hypothetical pipe break could take place in the drywell where high-energy piping is located. Pipe breaks are not postulated for the torus because high energy piping is not located in the wetwell.

The available flow path for insulation to reach the wetwell is through one of the eight vent pipes that connect the drywell to the torus (see Figure L-5). The location of these openings is X-5H (Figure L-6). Jet deflector plates, 8 feet 10 inches in diameter, guard the entrance to the vent pipes. Figure L-7 shows that there is a two foot gap between the deflector plate and the drywell wall through which insulation debris could enter. Since there are 20 supports, attaching the plate to the drywell walls on approximately 1 foot 4 inch centers, the largest section of insulation that could enter the vent pipe is limited to this spacing, i.e., 24 inches by 16 inches.

The drywell has a grating floor at the 901 foot level (see Figure L-8). The grating has an opening of 4 inches by 1-3/16 inch, and insulation debris resulting from jet effects and pipe whip of a break above the floor grating would be retained on this flooring. At the 901 foot level, the grating covers the entire level with the exception of penetrations for piping, the stairwell, and the control rod drive removal cart chute.

Insulation debris small enough to pass through the grating would normally land on the concreted bottom of the drywell (elevation 888 feet). (A postulated exception to this route occurs when the debris, after passing through the grating, encounters the drywell wall whose curvature could guide some of the material directly into the vent pipe opening.) Similarly, insulation coming off piping located below the grating floor would also land on the concrete base of the drywell. Due to the elevated location of the vent pipes, the only way this insulation debris could enter these pipes would be if there is sufficient water accumulating on the drywell floor to float the insulation to the outer perimeter of the deflector plates.

Figure L-8 shows that the only major piping in the area below the floor grating is the recirculation piping. Since the insulation pieces from the recirculation piping are large, it is not considered likely that the pieces would enter the actual downcomer vent. Partial blockage of some of the openings in the perimeter of the deflector would have an insignificant effect on the containment vent system.

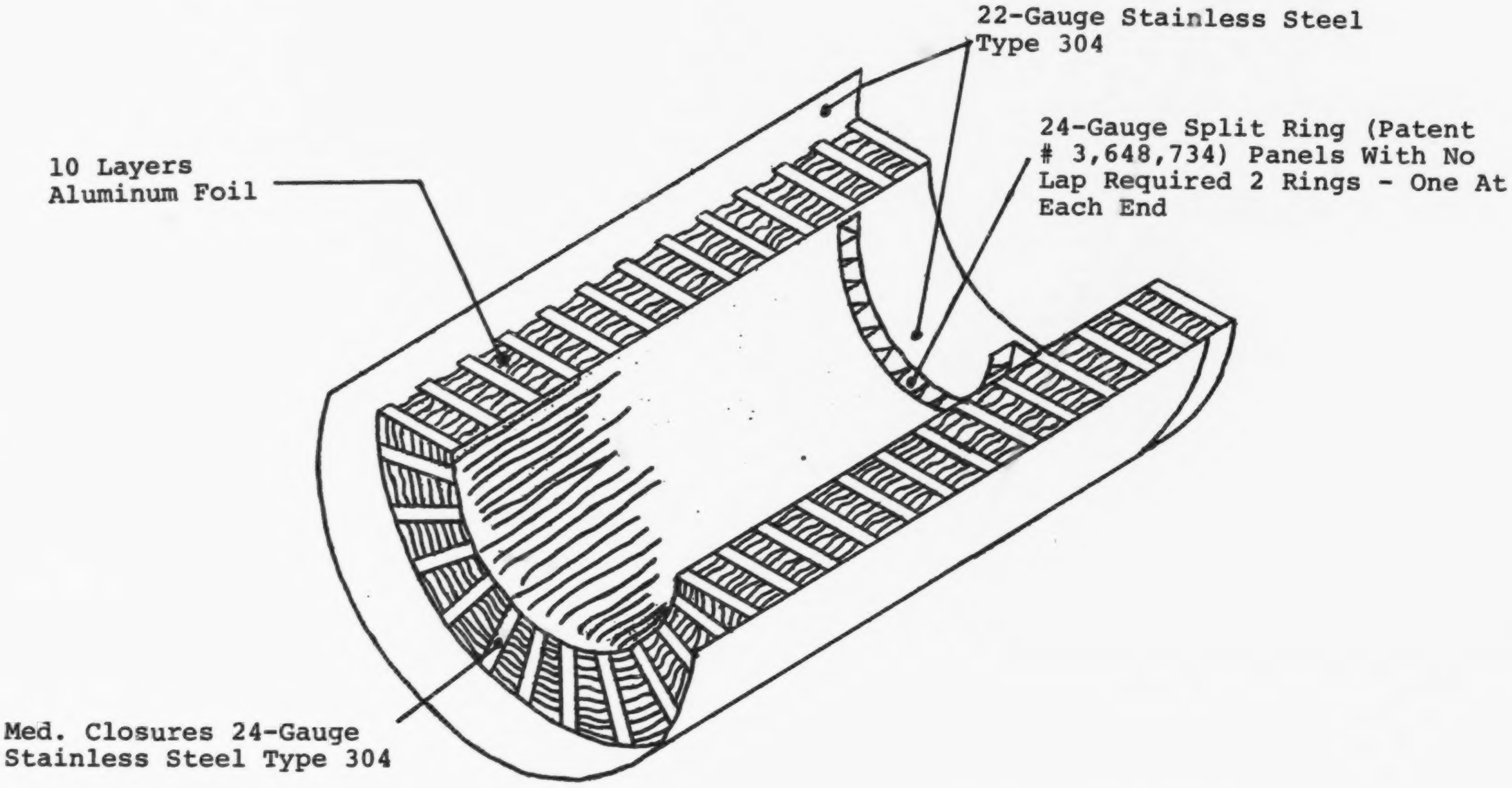
If some insulation works its way into the vent pipe, it would still face a tortuous path to the torus. Each of the eight 5 foot 11 inch vent pipes terminates in a 4 foot 2 inch ring header located 26 feet from the drywell. Insulation debris must negotiate a 90° turn upon reaching the ring header after sliding along a shallow angle in the vent pipe (Figure L-5). Downcomers off the ring headers limit the insulation size still further (21 inch pipe) as seen in Figure L-9. A "lip" exists where the downcomers connect to the ring header, further adding to the difficulty for debris to enter a downcomer.

The geometry of the downcomer and the pump suction lines is shown in Figure L-8. The various suction line intakes of the emergency core-cooling system pumps have screens which have twice the flow area needed to allow for blockage of 50 percent of the screen area (see Figure L-10). The location of each intake screen in a different area of the wetwell along with its excess screening capacity makes it unlikely that more than one core cooling pump suction would be impacted by a postulated pipe break. Even then, it is doubtful that the debris would be in sufficient quantity to block the flow area required for safe operation of the pump involved.

To ensure retention of all large particles falling from the upper levels of the drywell, it appears desirable to require that the floor grating at 901 feet 0 inch elevation be modified by some additional grating to cover the stairwell and control rod drive removal chute openings. This new grating should be designed to be removable but required by technical specifications to be locked in place during power operations.

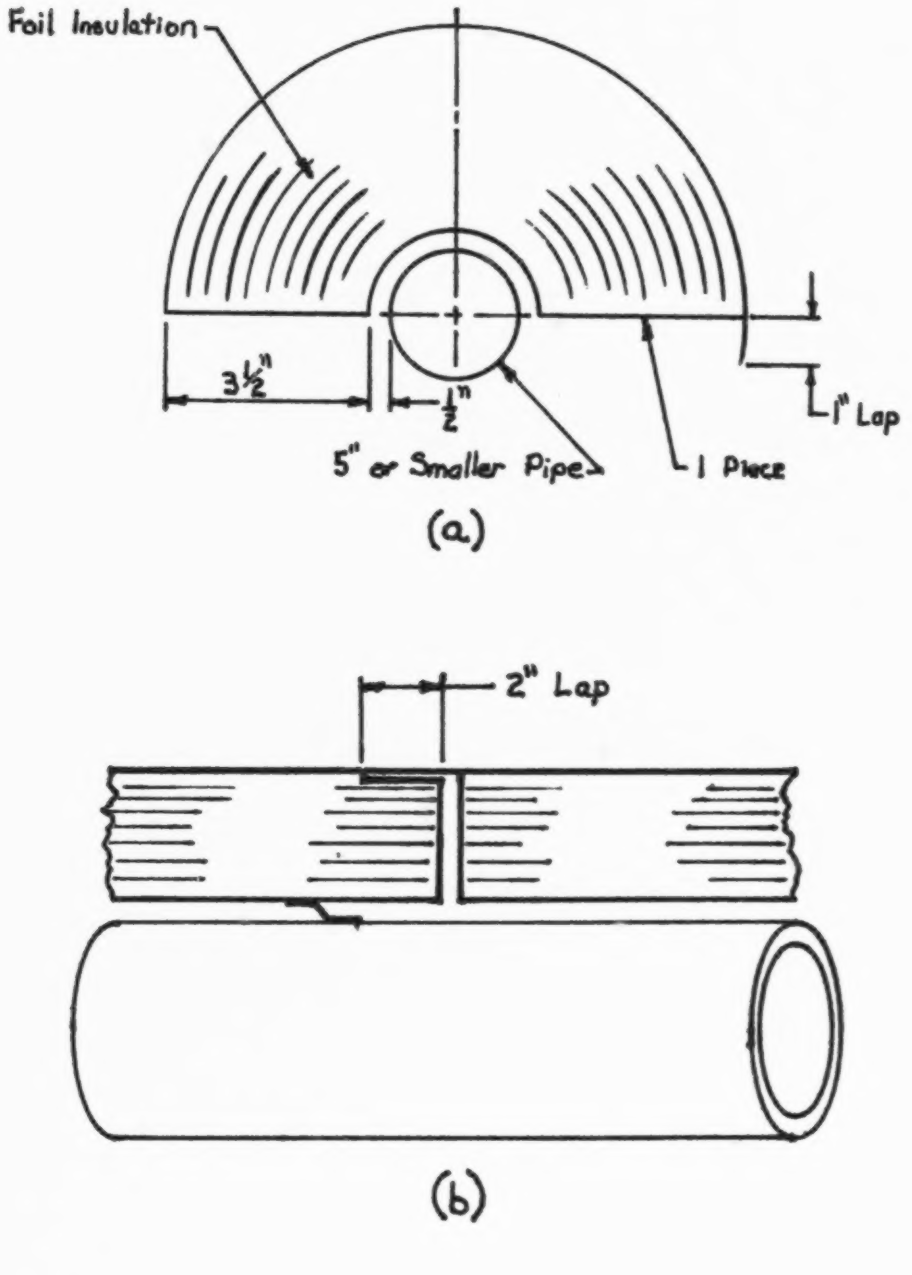
H. REFERENCES

1. Cooper Station, Final Safety Analysis Report, Nebraska Public Power District, Columbus, Nebraska.


22-Gauge Stainless Steel
Type 304
24-Gauge Split Ring (Patent # 3,648,734) Panels With No Lap Required 2 Rings - One At Each End
10 Layers Aluminum Foil
Med. Closures 24-Gauge Stainless Steel Type 304

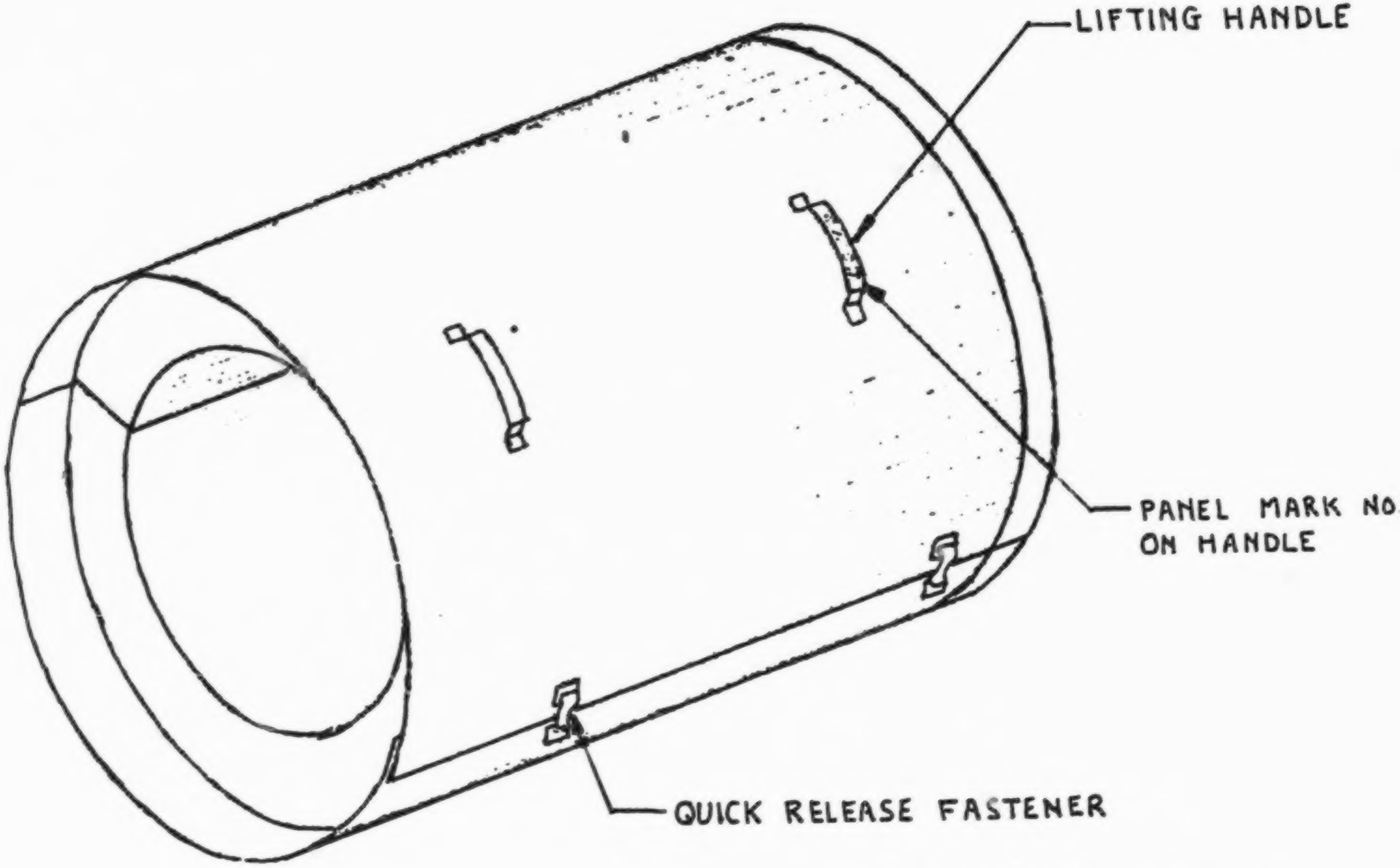
Courtesy Diamond Power

Figure L-1. Reflective insulation



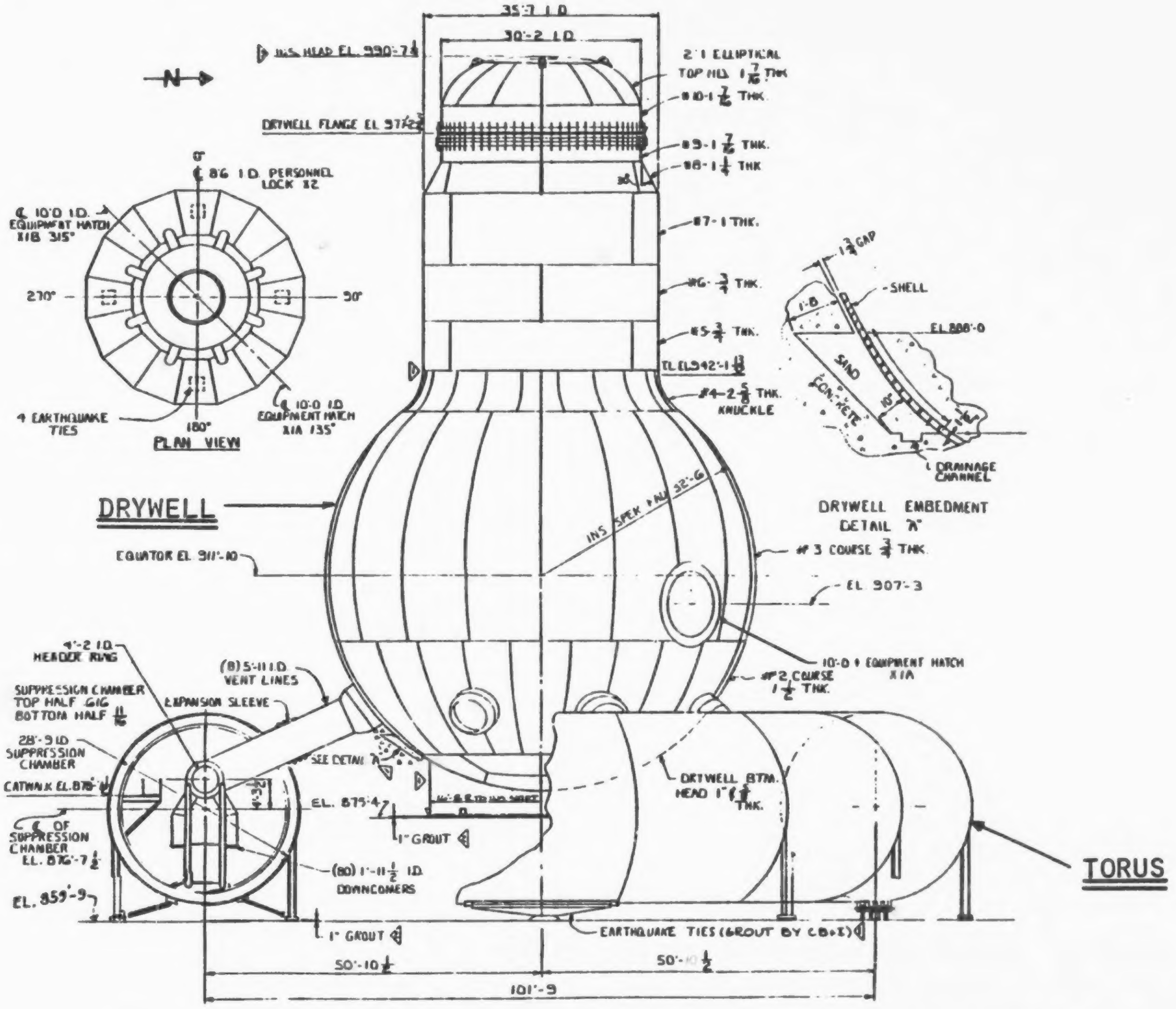
Foil Insulation
3½"
½"
5" or Smaller Pipe
1 Piece
1" Lap
(a)
2" Lap
(b)

Figure L-2. (a) Typical panel cross section, (b) Typical end lap


LIFTING HANDLE
PANEL MARK NO ON HANDLE
QUICK RELEASE FASTENER

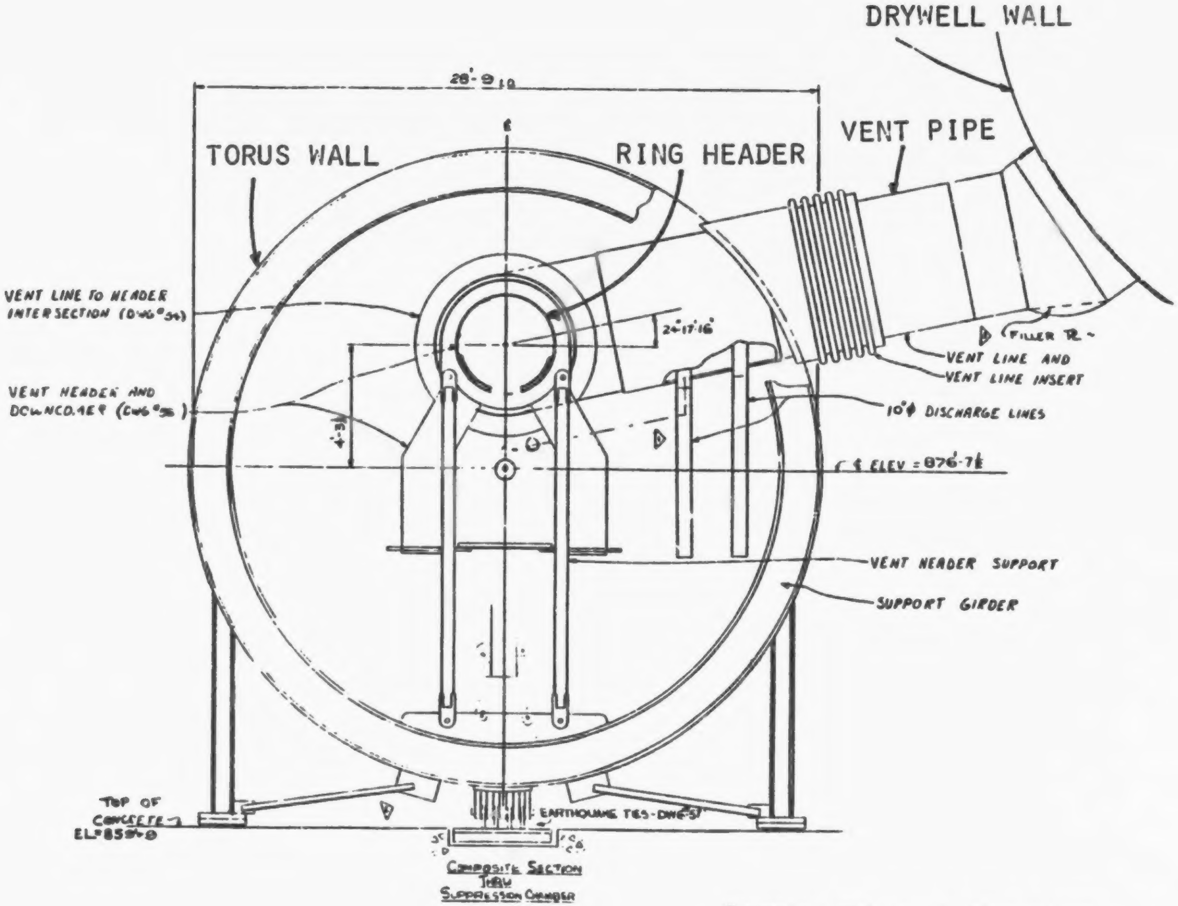
Courtesy Diamond Power

Figure L-3. Removable panel


35'-7 I.D.
30'-2 I.D.
INS. HEAD EL. 990'-7 3/4
2:1 ELLIPTICAL TOP HD. 1 7/16 THK
#10-1 7/16 THK.
DRYWELL FLANGE EL 97?'-2 3/4
#9-1 7/16 THK.
#8-1 1/4 THK
30°
#7-1 THK.
#6-3/4 THK.
#5-3/4 THK.
TL EL 942'-1 13/16
#4-2 5/8 THK. KNUCKLE
N
0°
℄ 8'6 I.D. PERSONNEL LOCK X2
℄ 10'0 I.D. EQUIPMENT HATCH X1B 315°
270°
90°
4 EARTHQUAKE TIES
180°
℄ 10'0 I.D. EQUIPMENT HATCH X1A 135°
PLAN VIEW
DRYWELL
INS. SPEK RAD. 32'-6
EQUATOR EL 911'-10
1 3/4 GAP
SHELL
1'-8
EL 888'-0
SAND
CONCRETE
10"
℄ DRAINAGE CHANNEL
DRYWELL EMBEDMENT DETAIL "A"
#3 COURSE 3/4 THK.
EL 907'-3
10'-0 Φ EQUIPMENT HATCH X1A
#2 COURSE 1 1/2 THK.
4'-2 I.D. HEADER RING
(8) 5'-11 I.D. VENT LINES
SUPPRESSION CHAMBER TOP HALF .616 BOTTOM HALF 11/16
EXPANSION SLEEVE
28'-9 I.D. SUPPRESSION CHAMBER
SEE DETAIL "A"
CATWALK EL. 878'
EL. 875'-4
℄ OF SUPPRESSION CHAMBER EL. 876'-7 1/2
1" GROUT
(80) 1'-11 1/2 I.D. DOWNCOMERS
EL. 859'-9
1" GROUT
DRYWELL BTM. HEAD 1" (?) THK.
EARTHQUAKE TIES (GROUT BY CB+I)
50'-10 1/2
50'-10 1/2
101'-9
TORUS

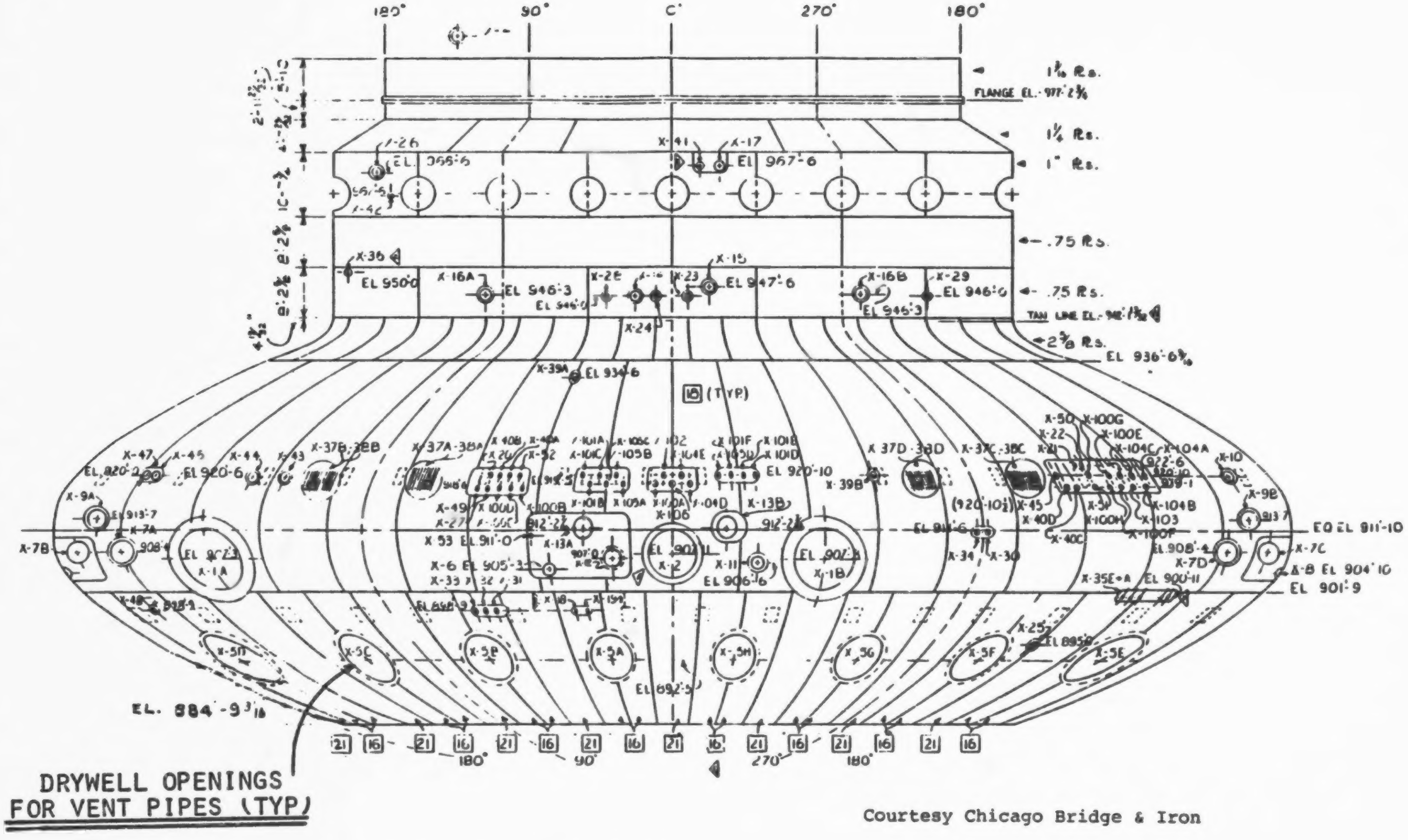
Courtesy Chicago Bridge & Iron

Figure L-4. Primary containment vessel, Cooper Station


DRYWELL WALL
28'-9 1/2
VENT PIPE
TORUS WALL
RING HEADER
VENT LINE TO HEADER
INTERSECTION (DWG 54)
24°17'16"
FILLER PL
VENT LINE AND
VENT LINE INSERT
VENT HEADER AND
DOWNCOMER (DWG 56)
10"φ DISCHARGE LINES
4'-3 1/2
℄ ELEV = 876'-7 1/2
VENT HEADER SUPPORT
SUPPORT GIRDER
TOP OF
CONCRETE
EL 859'-0
EARTHQUAKE TIES-DWG 57
COMPOSITE SECTION
THRU
SUPPRESSION CHAMBER

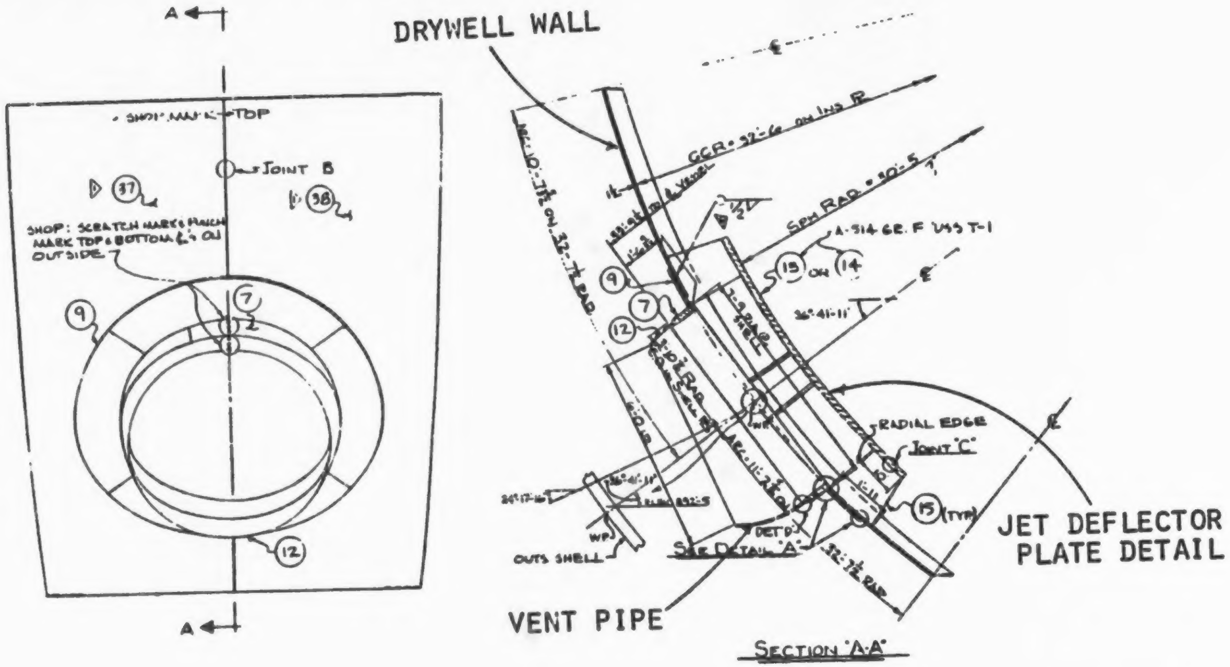
Courtesy Chicago Bridge & Iron

Figure L-5. Suppression chamber, Cooper Station


180°
90°
0°
270°
180°
1⅛ Rs.
FLANGE EL. 977'-2⅜
1¼ Rs.
1" Rs.
.75 Rs.
.75 Rs.
TAN LINE EL.
2⅝ Rs.
EL 936'-6⅜
X-26
EL 966'-6
X-41
X-17
EL 967'-6
X-36
EL 950'-0
X-16A
EL 946'-3
X-2E
X-23
X-15
EL 947'-6
X-16B
X-29
EL 946'-0
EL 945'-3
X-24
X-39A
EL 934'-6
16 (TYP)
X-47
X-46
X-44
X-43
EL 920'-2
EL 920'-6
X-37B-38B
X-37A-38A
X-40B
X-20
X-52
X-101A
X-101C
X-105B
X-104E
X-101F
X-101E
X-101D
EL 920'-10
X-39B
X-37D-38D
X-37C-38C
X-50
X-100G
X-22
X-100E
X-104C
X-104A
X-10
922'-6
919'-1
X-9A
EL 913'-7
X-7A
X-7B
908'-4
EL 902'-3
X-1A
X-49
X-100D
X-100B
X-27
912'-2
X-53
EL 911'-0
X-13A
X-101B
X-105A
X-104D
X-106
X-13B
912'-2
EL 902'-11
X-2
X-11
EL 906'-6
EL 902'-3
X-1B
(920'-10½)
X-45
X-40D
X-5F
X-100H
X-103
X-104B
X-100F
X-40C
X-9B
913'-7
EQ EL 911'-10
X-7C
X-7D
X-8 EL 904'-10
EL 908'-4
EL 901'-9
X-6 EL 905'-3
X-33
X-32
X-31
X-18
X-159
X-34
X-30
X-35E+A
EL 900'-11
X-48
EL 898'-3
X-5D
X-5C
X-5B
X-5A
X-5H
X-5G
X-5F
X-5E
X-25
EL 895'-0
EL 892'-3
EL. 884'-9³⁄₁₆
21
16
180°
90°
270°
180°
DRYWELL OPENINGS FOR VENT PIPES (TYP)

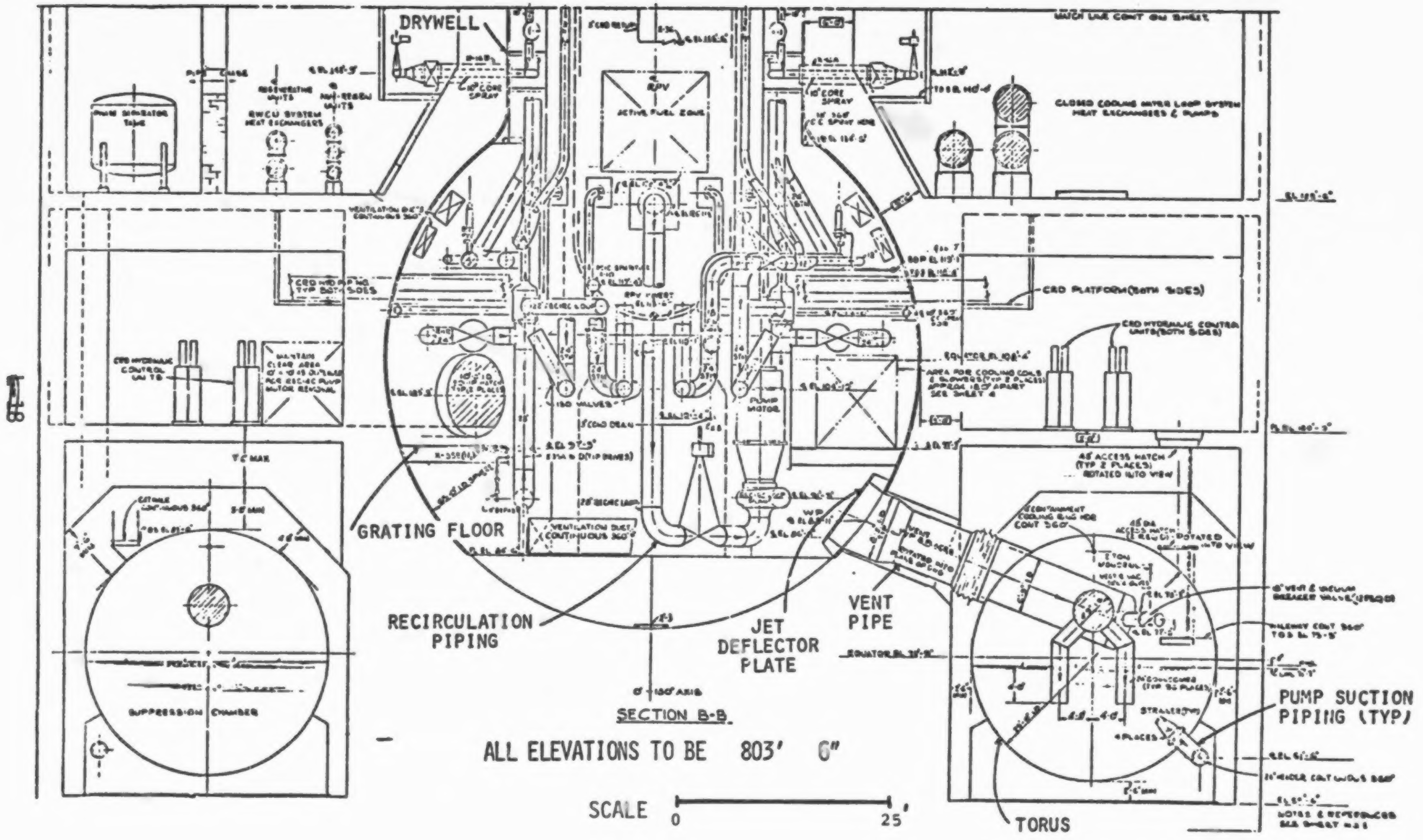
Courtesy Chicago Bridge & Iron

Figure L-6. Drywell shell stretchout, Cooper Station


A
SHOP MARK TOP
JOINT B
37
38
SHOP: SCRATCH MARK & PUNCH MARK TOP & BOTTOM ℄ ON OUTSIDE
9
7
2
12
A
DRYWELL WALL
℄
GCR = 32'-6 ON INS R
SPH RAD = 30'-5
A-516 GR. F USS T-1
13 OR 14
36°-41'-11"
9
7
12
RADIAL EDGE
JOINT "C"
15 (TYP)
WP
OUTS SHELL
SEE DETAIL "A"
DET'D
32'-7½ RAD
VENT PIPE
JET DEFLECTOR PLATE DETAIL
SECTION "A-A"

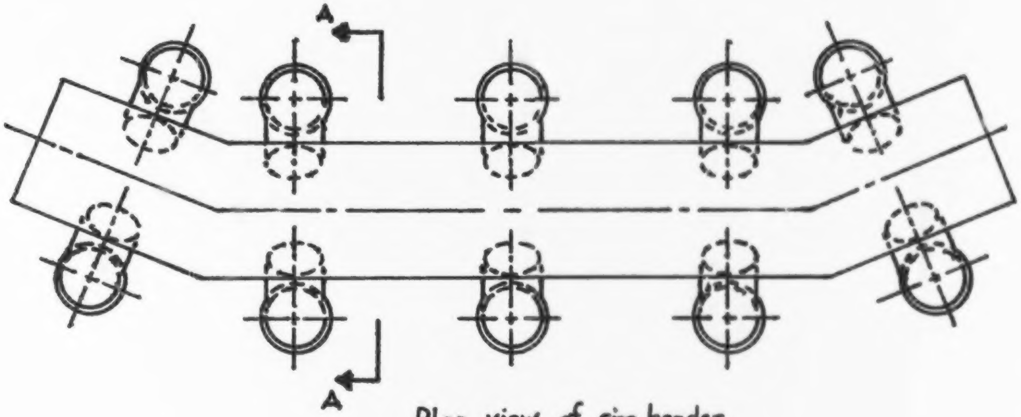
Courtesy Chicago Bridge & Iron

Figure L-7. Drywell, Cooper Station

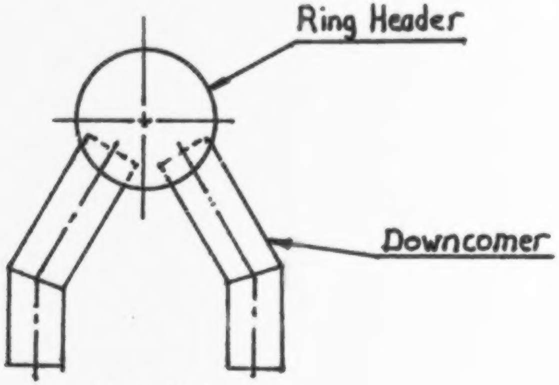

DRYWELL
RPV
ACTIVE FUEL ZONE
CLOSED COOLING WATER LOOP SYSTEM HEAT EXCHANGERS & PUMPS
CRD PLATFORM (BOTH SIDES)
CRD HYDRAULIC CONTROL UNITS (BOTH SIDES)
PUMP MOTOR
VENTILATION DUCT CONTINUOUS 360°
GRATING FLOOR
RECIRCULATION PIPING
JET DEFLECTOR PLATE
VENT PIPE
SUPPRESSION CHAMBER
PUMP SUCTION PIPING (TYP)
TORUS
SECTION B-B
ALL ELEVATIONS TO BE 803' 6"
SCALE
0
25'

Courtesy Chicago Bridge & Iron

Figure L-8. Reactor containment, Cooper Station



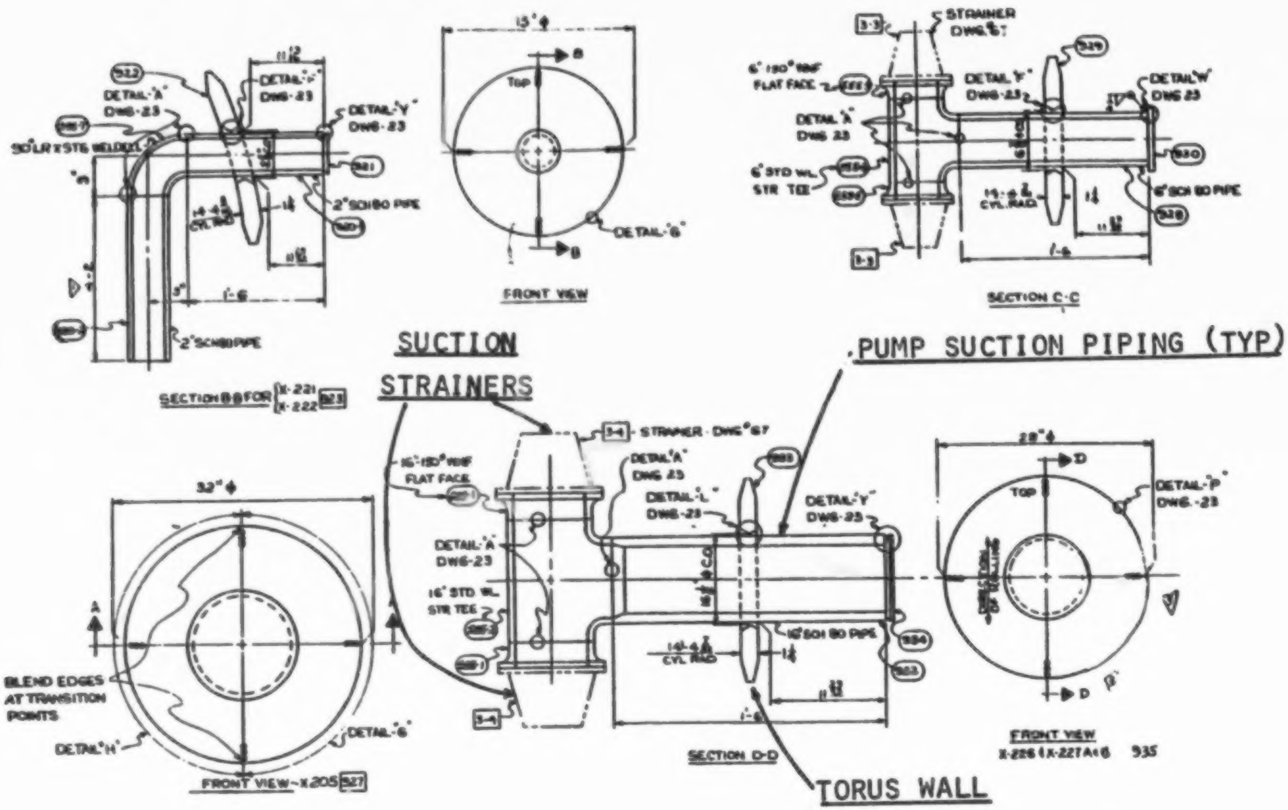
Plan view of ring header


Ring Header
Downcomer

Sect. A-A

Courtesy Chicago Bridge & Iron

Figure L-9. Suppression chamber vents, Cooper Station


SUCTION STRAINERS
PUMP SUCTION PIPING (TYP)
TORUS WALL
SECTION B-B FOR X-221 X-222
FRONT VIEW
SECTION C-C
STRAINER DWG 67
DETAIL 'A' DWG-23
DETAIL 'Y' DWG-23
DETAIL 'W' DWG 23
DETAIL 'G'
DETAIL 'H'
DETAIL 'P' DWG-23
DETAIL 'L' DWG-23
2" SCH 80 PIPE
6" SCH 80 PIPE
16" SCH 80 PIPE
6" STD WL STR TEE
16" STD WL STR TEE
16"-150# RF FLAT FACE
6" 150# RF FLAT FACE
90°LR X STD WELD ELL
CYL RAD
BLEND EDGES AT TRANSITION POINTS
32" φ
28" φ
15" φ
1'-6
FRONT VIEW~X205
SECTION D-D
FRONT VIEW X-226 & X-227A&B

Courtesy Chicago Bridge & Iron

Figure L-10. Suppression chamber penetrations, Cooper Station

APPENDIX M

WASHINGTON PUBLIC POWER SUPPLY SYSTEM
NUCLEAR PROJECT 2:

PRELIMINARY ASSESSMENT OF INSULATION DEBRIS GENERATED DURING A PIPE BREAK EVENT

A. INTRODUCTION

This report documents the information gathered by Burns and Roe's survey of thermal insulation inside the primary containment of the 1150 MWe, BWR/5 Mark II containment Washington Public Power Supply System (WPPSS) Nuclear Project 2 scheduled for commercial operation in 1983.

The information gathered depicts the following:

1. The arrangement of all piping within the primary containment including high energy fluid piping.
2. The location and configuration of the intakes for emergency core cooling; and the communicating paths by which debris generated by a major pipe break could reach the emergency recirculating sump.
3. Details of the insulation that could be dislodged and become a source of debris as the result of a major break.

Reflective metallic insulation, manufactured and installed in panels, is used exclusively within the primary containment for both equipment and piping. No other type of nonmetallic insulation is utilized inside primary containment.

B. LISTING OF INPUT DRAWINGS AND OTHER DOCUMENTS

This section provides a listing of drawings showing details of the Mark II containment vessel, jet deflectors, platforms in containment, reactor building arrangements, and all piping, including instrumentation piping inside containment. Also included are specifications for purchase of the reflective metallic insulation. Reflective insulation drawings for the piping systems have not been prepared as of this date; however, samples of other jobs can be used for analysis purposes. With this exception, sufficient information is included herein for an organization to conduct an independent debris analysis.

1. Documentation

   Section 15E, Specifications for Procurement of Reflective Insulation

2. Drawings

S794	Structural Containment Vessel Sh. 1
S795	Structural Containment Vessel Sh. 2
S796	Structural Containment Vessel Sh. 3
S797	Structural Containment Vessel Sh. 4
S798	Structural Containment Vessel Sh. 5
S799	Structural Containment Vessel Sh. 6
S862	Structural Reactor Building Jet Deflector Details Sh. 1
S863	Structural Reactor Building Jet Deflector Details Sh. 2
S864	Structural Reactor Building Jet Deflector Details Sh. 3
S839	Structural Reactor Building Radial Beams Plan & Detail
SM046	Study of Platforms and Access in Containment Vessel

b. Mechanical Drawings

M567	General Arrangement Plan El. 422'-3" & El. 441'-0" & 444'-0"
M568	General Arrangement Plan El. 471'-0" & El. 501'-0"
M569	General Arrangement Plan El. 522'-0" & El. 548'-0"
M570	General Arrangement Plan El. 572'-0" & El. 606'-10-1/2"
M609	Instrumentation Process (PI) Plan at Floor El. 501'-0" (0 to 180° AZ) Reactor Building
M623	Instrumentation Process (PI) Plan at Floor El. 501'-0" (180 to 360° AZ) Reactor Building
M624	Instrumentation Process (PI) Plan at Platform El. 512'-9-1/2" Reactor Building
M625	Instrumentation Process (PI) Plan at Floor El. 522'-0" Reactor Building
M626	Instrumentation Process Plan at Platform El. 541'-3-3/4" Reactor Building
M627	Instrumentation Process (PI) Plans at El. 560'-0" & El. 583'-1-1/4" Reactor Building
M628	Instrumentation Process (PI) Penetration Schedule, Sections & Details Reactor Building
M629	Instrumentation Process (PI) Partial Plans, Sections & Details Reactor Building
M695	Main & Auxiliary Steam & Misc. Drain Piping Plan at El. 501'-0" Reactor Building
M697	Main & Auxiliary Steam, S.V. Vent & Misc. Drain Piping, Sections and Details Reactor Building
M700	Hydraulic Piping for Reactor Recirculating Control Valve Plans and Sections Reactor Building
M702	RHR, LPCS, RCC, FPC, SLC, CPR Plan, Sections & Details El. 440'-0" and El. 441'-0" Reactor Building
M704	RHR, LPCS, RCC, FPC, SLC, CPR Plan, Sections & Details El. 501'-0" Reactor Building
M705	RHR, LPCS, RCC, FPC, SLC, CPR Plan, Sections & Details El. 522'-0" Reactor Building
M706	RHR, LPCS, RCC, FPC, SLC, CPR Partial Plans, Sections & Details El. 548'-0" Reactor Building
M708	RHR, LPCS, RCC, FPC, SLC, CPR Partial Plan, Sections & Details Reactor Building
M709	RHR, LPCS, RCC, FPC, SLC, CPR Sections & Details Reactor Building
M710	RHR, LPCS, RCC, FPC, SLC, CPR Partial Plan and Sections Reactor Building
M712	RFW, RCIC, HPCS, SW RWCU, RCC, TSW El. 441'-0" Reactor Building
M713	RFW, RCIC, HPCS, SW RWCU, RRC, TSW El. 501'-0" Reactor Building
M714	RFW, RCIC, HPCS, SW RWCU, RRC, TSW El. 522'-0" Reactor Building
M715	RFW, RCIC, HPCS, SW RWCY, RRC, TSW El. 548'-0" Reactor Building

M716	RFW, RCIC, HPCS, SW RWCU, RRC, TSW Misc. Plan, Sections & Details Reactor Building
M720	Control Rod Drive Piping Plan at El. 522'-0" & Sections Reactor Building
M721	Control Rod Drive Piping Plan & Sections - Containment Vessel & Reactor Building
M814	HVAC Primary Containment Plans
M815	HVAC Primary Containment Sections and Details
M885	Reactor Pressure Vessel Reflective Insulation Installation Sequence
M886	Reactor Pressure Vessel Inservice Inspection Pole Track Layout

c. Containment Composite Drawings

SM246	Suppression Pool Composite Plan at El 435'-3" Reactor Building
SM250	Suppression Pool Composite Sections "1-1 & 2-2" Reactor Building
SM251	Suppression Pool Composite Sections "3-3 & 4-4" Reactor Building
SM260	Suppression Pool Composite Sections "5-5 & 6-6" Reactor Building
SM168	Containment Composite Plan at El. 499'-6"
SM186	Containment Composite Plan at El. 501'-0" Azimuth 0 to 180°
SM187	Containment Composite Plan at El. 501'-0" Azimuth 180 to 360°
SM189	Containment Composite Plan at El. 512'-9-1/2" Azimuth 0 to 180°
SM190	Containment Composite Plan at El. 512'-9-1/2" Azimuth 180 to 360°
SM182	Containment Composite Plan at El. 524'-3-7/8" Azimuth 0 to 180°
SM183	Containment Composite Plan at El. 524'-3-7/8" Azimuth 180 to 360°
SM184	Containment Composite Plan at El. 541'-3-3/4" and Section
SM185	Containment Composite Flat Development 180 to 360° El. 499'-6" to El. 541'-3-3/4"
SM135	Containment Composite at El 545'-6"
SM197	Containment Composite Plan at El. 556'-6" and Section
SM198	Containment Composite Plan at El. 565'-9" and Sections
SM136	Containment Composite Flat Development El. 541'-3-3/4" to El. 567'-4-1/2" 0 to 180° Azimuth
SM261	Containment Composite Plan at El. 583'-1-1/4" and Sections
SM191	Containment Composite Sections "1-1 & 2-2"
SM192	Containment Composite Sections "3-3 & 4-4"
SM193	Containment Composite Sections "5-5 & 6-6"
SM194	Containment Composite Sections "7-7 & 8-8"

d. Isometric Piping Drawings of Piping Systems Inside Containment

M200	Sh.1	Low Pressure Core Spray
M200	Sh.2	High Pressure Core Spray
M200	Sh.3	RHR/LPCI Mode C
M200	Sh.4	RHR/LPCI Mode B
M200	Sh.5	RHR/LPCI Mode A
M200	Sh.6	RHR Shutdown Cooling
M200	Sh.7	RHR Shutdown Cooling
M200	Sh.8	RHR Shutdown Cooling
M200	Sh.9 to 26	Main Steam Relief Valve Discharge Piping
M200	Sh.27	Reactor Feedwater Line A
M200	Sh.29	Reactor Feedwater Line B
M200	Sh.30	RHR Condensing Mode
M200	Sh.31	Main Steam Loop A
M200	Sh.32	Main Steam Loop B
M200	Sh.33	Main Steam Loop C
M200	Sh.34	Main Steam Loop D
M200	Sh.35	Standby Liquid Control
M200	Sh.36	Reactor Water Cleanup System/Reactor Recirculation System
M200	Sh.38 to 43, 152, 153, 155	Reactor Closed Cooling
M200	Sh.44	Reactor Recirculation Pump A Discharge Piping
M200	Sh.45	Reactor Recirculation Pump B Discharge Piping
M200	Sh.46	Reactor Recirculation Pump A Suction
M200	Sh.47	Reactor Recirculation Pump B Suction
M200	Sh.48	RHR - Upper Drywell Ring Spray Header
M200	Sh.49	RHR - Lower Drywell Ring Spray Header
M200	Sh.51	RRC - Vessel Drain
M200	Sh.52	Main Steam RPV Head Vent
M200	Sh.53	Main Steam Valves Drainage
M200	Sh.72 95, 97, 98, 200	Drain Piping
M200	Sh.99	Control Air Piping
M200	Sh.171	Containment Exhaust Piping
M200	Sh.172	Containment Supply Piping
M200	Sh.201	Hydraulic Piping for Power Unit A
M200	Sh.202	Hydraulic Piping for Power Unit B

C. LISTING OF PIPING SYSTEMS INSIDE CONTAINMENT CONTAINING INSULATION

This section provides a list of the systems inside primary containment containing reflective metallic insulation. The list includes the system, nominal pipe sizes inside containment, and the isometric drawing number which depicts the dimensions of the pipe routing inside containment. The isometric drawings for each system contain design information such as piping material, design pressure, design temperature, pipe diameter schedule and wall thickness.

System	Nominal Sizes (inches)	Isometric Drawing Number
Low Pressure Core Spray	12, 10, 4	M200 Sh. 1
High Pressure Core Spray	12, 10, 4	M200 Sh. 2
RHR/LPCI Mode C	14, 12	M200 Sh. 3
RHR/LPCI Mode B	14, 12	M200 Sh. 4
RHR/LPCI Mode A	14, 12	M200 Sh. 5
RHR Shutdown Cooling	20, 12	M200 Sh. 6,7&8
Reactor Feedwater Line A	24, 18, 12	M200 Sh. 27
Reactor Feedwater Line B	24, 18, 12	M200 Sh. 28
RCIC RPV Head Spray	6	M200 Sh. 29
RHR Condensing Mode	10, 4	M200 Sh. 30
Main Steam Loop A	26	M200 Sh. 31
Main Steam Loop B	26	M200 Sh. 32
Main Steam Loop C	26	M200 Sh. 33
Main Steam Loop D	26	M200 Sh. 34
Standby Liquid Control	1-1/2	M200 Sh. 35
Reactor Water Cleanup System/Reactor Recirculation System	6, 4, 2	M200 Sh. 36
Reactor Recirculation Pump A Discharge Piping	24, 16, 12 10, 8	M200 Sh. 44
Reactor Recirculation Pump B Discharge Piping	24, 16, 12	M200 Sh. 45
Reactor Recirculation Pump A Suction Piping	24, 20, 4	M200 Sh. 46
Reactor Recirculation Pump B Suction Piping	24, 4	M200 Sh. 47
RRC Vessel Drain	4, 3, 2	M200 Sh. 51
Main Steam RPV Head Vent	2	M200 Sh. 52
Main Steam Valves Drainage	3, 2	M200 Sh. 53

D. TYPICAL INSULATION DETAILS

Reflective metallic insulation is used exclusively for the reactor pressure vessel, reactor recirculating pumps, and all piping requiring insulation. The insulation used for piping is typically two feet or longer in length, 3-4 inches thick and split into two sections with each section covering half of the pipe. These sections have 24 gauge stainless steel outer sheets which fully enclose the 2 mil layer stainless steel inner sheets. The inner sheets are built up of two to three sheets per inch of insulation thickness.

The insulation panels used for the reactor pressure vessel are typically 2 feet by 6 feet, and are encased by 18 gauge stainless steel. The inner sheets are 6 mils of aluminum up to the top of the sacrificial shield wall and 2 mils of stainless steel above the shield wall.

All panels on piping covering areas which require inservice inspection, such as welds, are fastened by quick release buckle bands. Nonremovable insulation panels around pipes are fastened, one to another, using self-tapping screws. The fasteners have been designed to be weaker than the panels, and therefore, it is possible that some panels near a pipe break will be blown away but that the panels themselves will not be sheared open.

The insulation contractor, Transco, has not prepared the insulation drawings for the WNP-2. These drawings are normally prepared one year prior to commercial operation to avoid costly changes in insulation.

E. PIPE BREAK LOCATIONS

A list of drawings showing the pipe break locations for high energy piping inside the primary containment is included in this section. Six hundred eleven (611) pipe break jet trajectories are shown on these drawings. An additional twenty to thirty pipe break locations are anticipated for this project. The 611 pipe break jet trajectories represent approximately 240 pipe breaks.

The pipe break points are shown as node points on the isometric piping drawings which are listed in Section C of this appendix.

List of Drawings Showing Pipe Break Locations

SM168PB	Pipe Breaks Containment Composite Plan at El. 499'-6"
SM186PB	Pipe Breaks Containment Composite Plan at El. 501'-0" Azimuth 0 to 180°
SM187PB	Pipe Breaks Containment Composite Plan at El. 501'-0" Azimuth 180 to 360°
SM190PB	Pipe Breaks Containment Composite Plan at El. 512'-9-1/2" Azimuth 180 to 360°
SM189PB	Pipe Breaks Containment Composite Plan at El. 512'-9-1/2" Azimuth 0 to 180°
SM183PB	Pipe Breaks Containment Composite Plan at El. 524'-3-7/8" Azimuth 180 to 360°
SM182PB	Pipe Breaks Containment Composite Plan at El. 524'-3-7/8" Azimuth 0 to 180°
SM188PB	Pipe Breaks Containment Composite Plan at El. 541'-3-3/4"
SM184PB	Pipe Breaks Containment Composite Flat Development 0 to 180° El. 499'-6" to 541'-3-3/4"
SM185PB	Pipe Breaks Containment Composite Flat Development 180 to 360° El. 499' to El. 541'

SM135PB	Pipe Breaks Containment Composite Plan at El. 545'-6"
SM197PB	Pipe Breaks Containment Composite Plan at El. 556'-5" and Section
SM198PB	Pipe Breaks Containment Composite Plan at El. 565'-9" and Section
SM136PB	Pipe Breaks Containment Composite Flat Development El. 541'-3-3/4" to El. 567'-4-1/2" and Sections
SM261PB	Pipe Breaks Containment Composite Plan at El. 583-1-1/4" and Sections
SM101PB	Pipe Breaks Containment Composite Sections 1-1 and 2-2
SM192PB	Pipe Breaks Containment Composite Sections 3-3 and 4-4
SM193PB	Pipe Breaks Containment Composite Sections 5-5 and 6-6
SM194PB	Pipe Breaks Containment Sections 7-7 and 8-8

F. FSAR REFERENCES ON PERTINENT INSULATION QUESTIONS

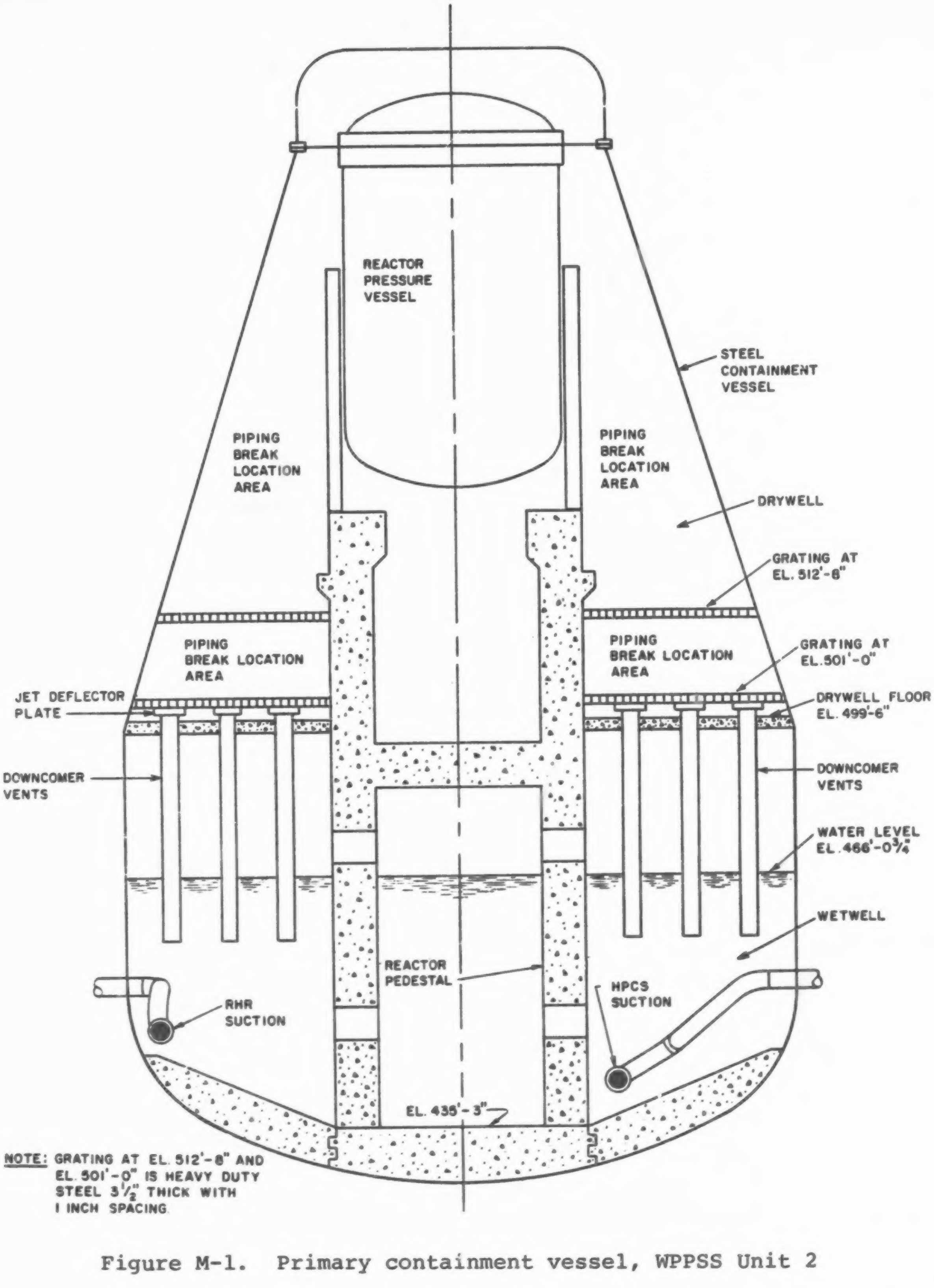
As of this date, questions have not been asked in connection with the FSAR submittal on this concern.

G. PRELIMINARY INSULATION DEBRIS HAZARD ANALYSIS

Figure M-1 is a simplified sketch of WPPSS No. 2 primary containment vessel. A hypothethical pipe break could take place in the drywell where high energy piping is located. Pipe breaks are not postulated in the wetwell as high or medium energy piping is not located in the wetwell. Insulation debris resulting from the jet effects and pipe whip of a break above the floor grating at elevation 512'-8" would land on this grating and not proceed behond this point. The floor grating shown at elevation 512'-8" and elevation 501'-0" is heavy duty steel 3-1/2 inches thick with 1 inch spacing. At the 512'-8" level, the floor grating covers the entire level with the exception of penetrations for piping. At the 501'-0" level, the floor grating covers approximately 80 percent of the level ((see Figure M-2). For pipe breaks below the 512'-8" level, insulation pieces falling in the open grating areas would strike the jet deflector (Figure M-3) plates located at the top of each downcomer or the drywell floor and not reach the downcomers. A small amount of reflective metallic insulated reactor water cleanup system/reactor recirculation system piping is located underneath the 501'-0" level grating as shown in Figure M-2. This piping is 4 inches in diameter and the insulation debris could lodge against the outer perimeter of the jet deflectors. Since the insulation pieces (see Figure M-4) would be larger than the openings in the jet deflector, it is not considered possible that the panel would enter the actual downcomer vent. As the amount of piping in this area is small and the number of downcomers is large (102), the partial blockage of several jet deflectors would have an insignificant effect on the containment vent system.

It is possible for some pieces of insulation from smaller piping (less than 4 inches) to work their way down into a downcomer vent and enter the wetwell as the result of a pipe break. However, it is not reasonable to expect that insulation debris in any quantity would find its way into the wetwell through the downcomers due to the tortuous path it would have to take.

Furthermore, the various suction line intakes of the emergency core cooling system pumps in the wetwell (see Figure M-5) have screens which have twice the flow area needed to allow for blockage of 50 percent of the screen area. The location of each intake screen in a different area of the wetwell along with its blockage capability makes it unlikely that more than one emergency core cooling pump suction would be impacted by a pipe break event. Even then it is doubtful that the debris would be in sufficient quantity to block the flow area required for safe operation of the pump involved.


REACTOR PRESSURE VESSEL
STEEL CONTAINMENT VESSEL
PIPING BREAK LOCATION AREA
PIPING BREAK LOCATION AREA
DRYWELL
GRATING AT EL. 512'-8"
PIPING BREAK LOCATION AREA
PIPING BREAK LOCATION AREA
GRATING AT EL. 501'-0"
JET DEFLECTOR PLATE
DRYWELL FLOOR EL. 499'-6"
DOWNCOMER VENTS
DOWNCOMER VENTS
WATER LEVEL EL. 466'-0¾"
WETWELL
REACTOR PEDESTAL
RHR SUCTION
HPCS SUCTION
EL. 435'-3"

NOTE: GRATING AT EL. 512'-8" AND EL. 501'-0" IS HEAVY DUTY STEEL 3½" THICK WITH 1 INCH SPACING.

Figure M-1. Primary containment vessel, WPPSS Unit 2

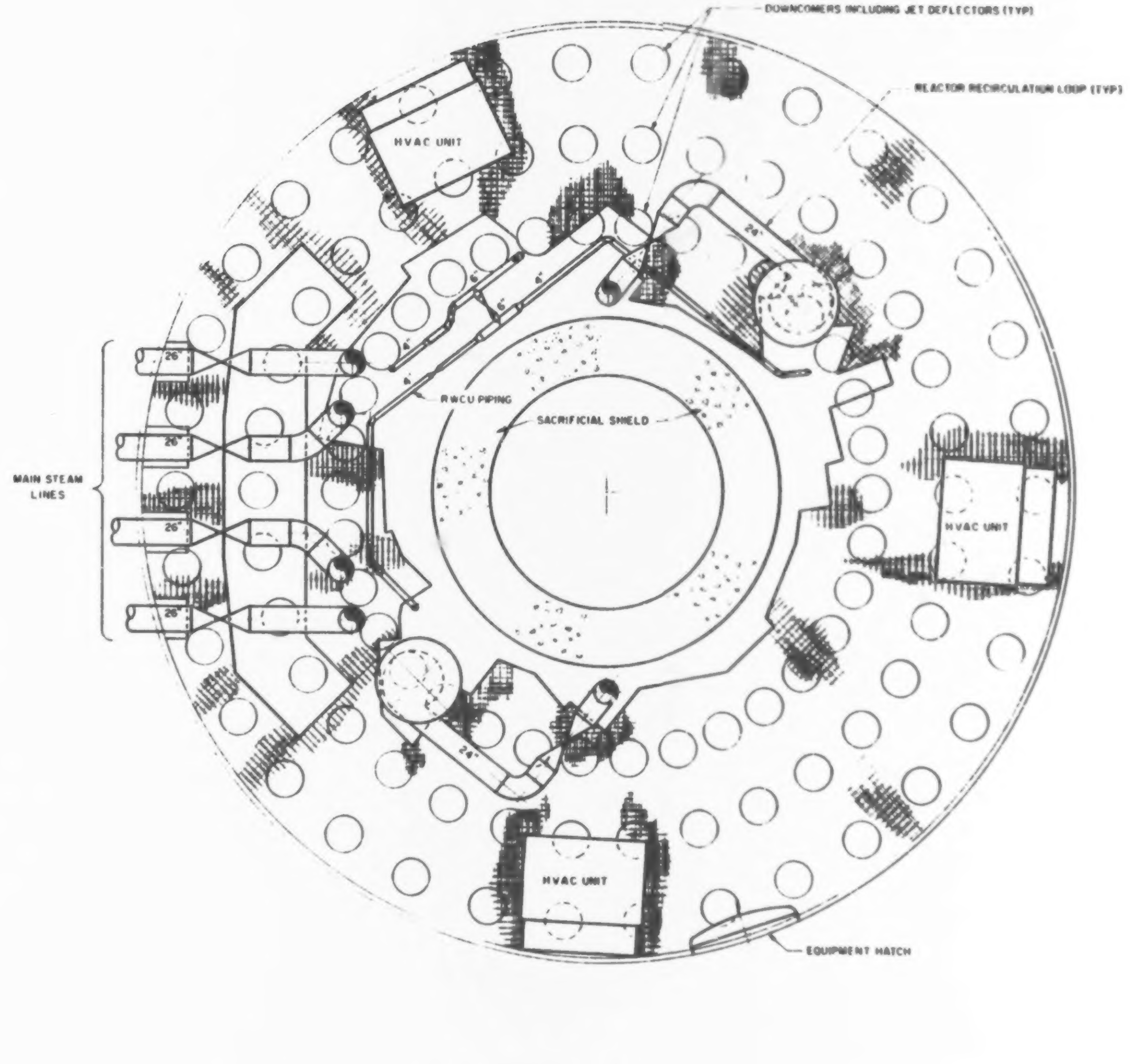

DOWNCOMERS INCLUDING JET DEFLECTORS (TYP)
REACTOR RECIRCULATION LOOP (TYP)
HVAC UNIT
HVAC UNIT
HVAC UNIT
24"
24"
26"
26"
26"
26"
6"
6"
6"
RWCU PIPING
SACRIFICIAL SHIELD
MAIN STEAM LINES
EQUIPMENT HATCH

Figure M-2. Composite at El.501'0", primary containment, WPPSS Unit 2

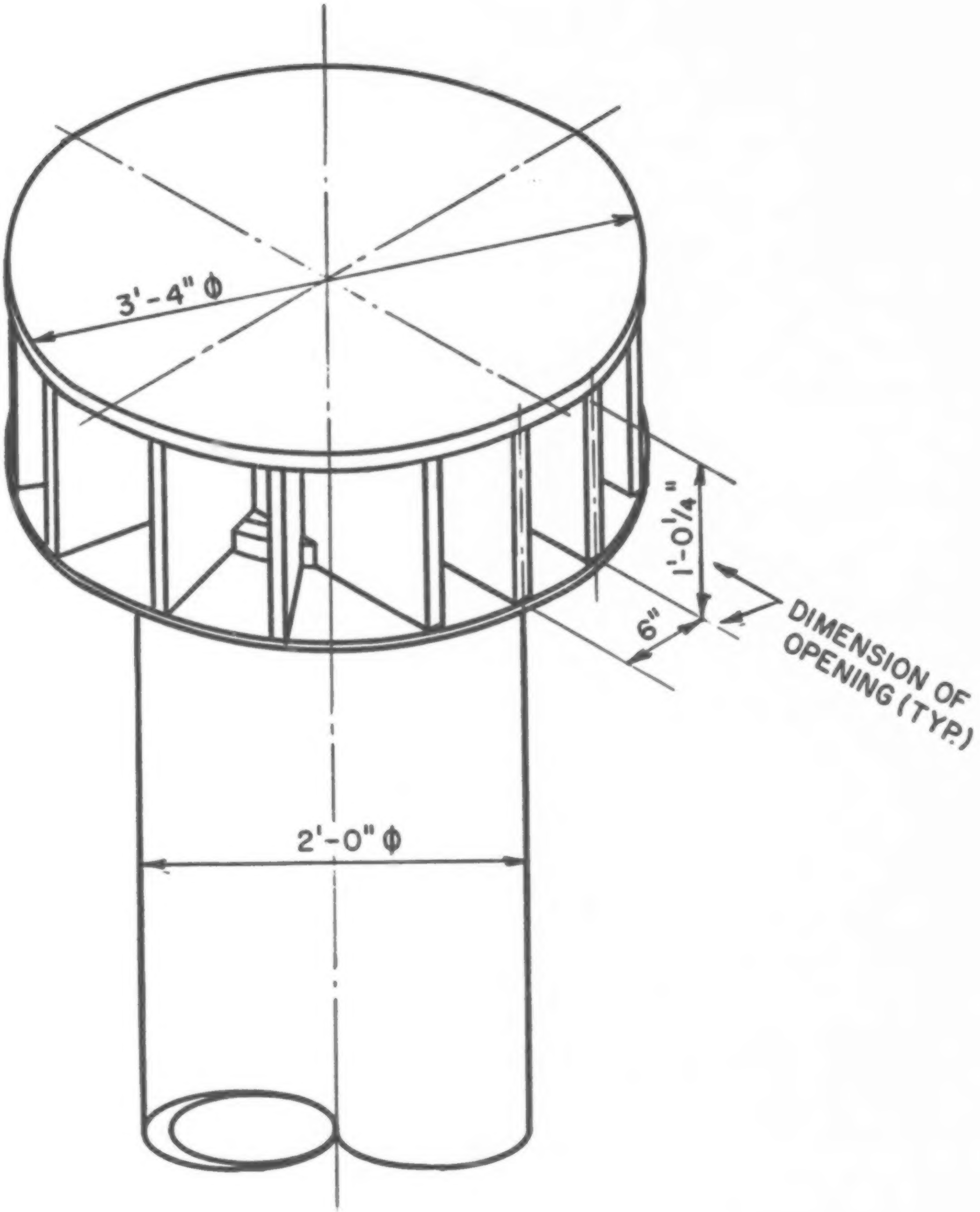

3'-4" Φ
1'-0¼"
6"
DIMENSION OF OPENING (TYP.)
2'-0" Φ

Figure M-3. Jet deflector with 24" Ø downcomer

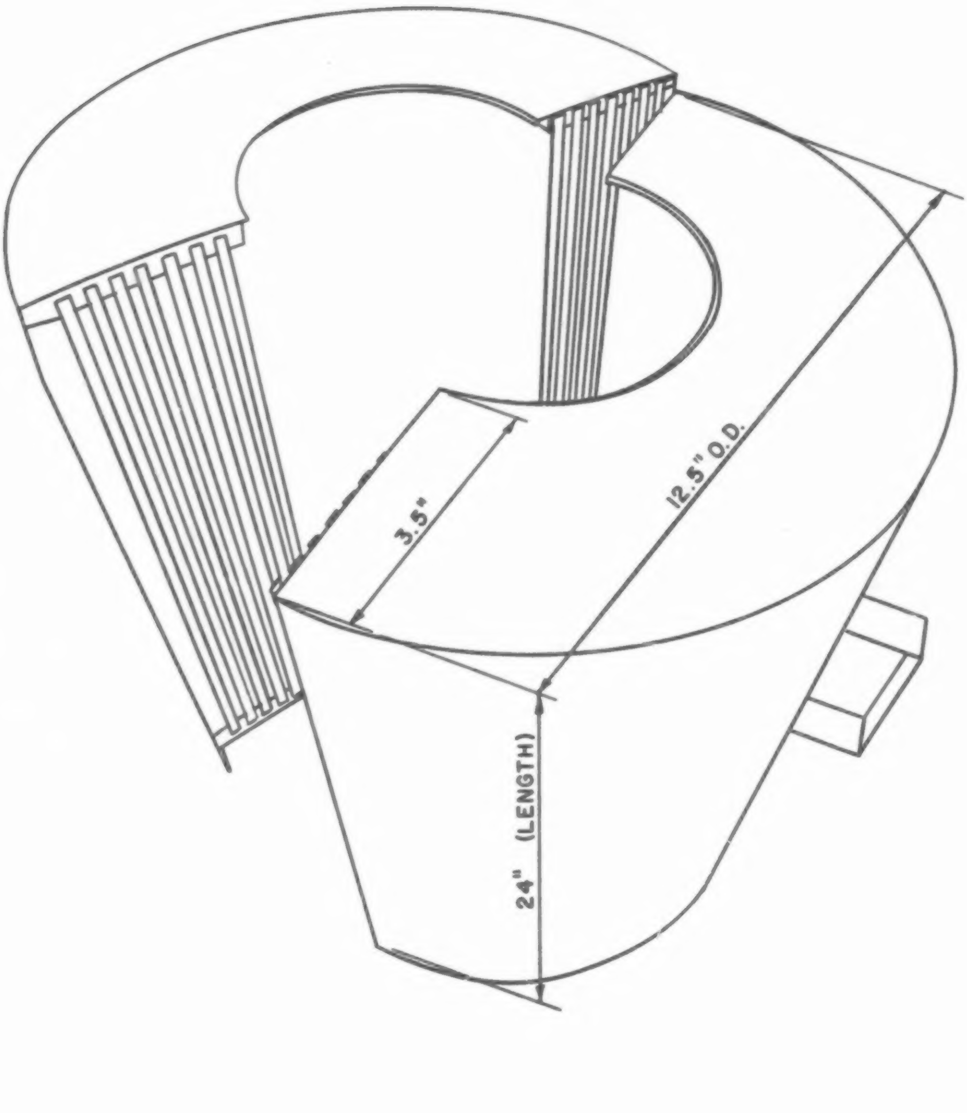

3.5"
12.5" O.D.
24" (LENGTH)

Figure M-4. Reflective insulation for a 4" pipe

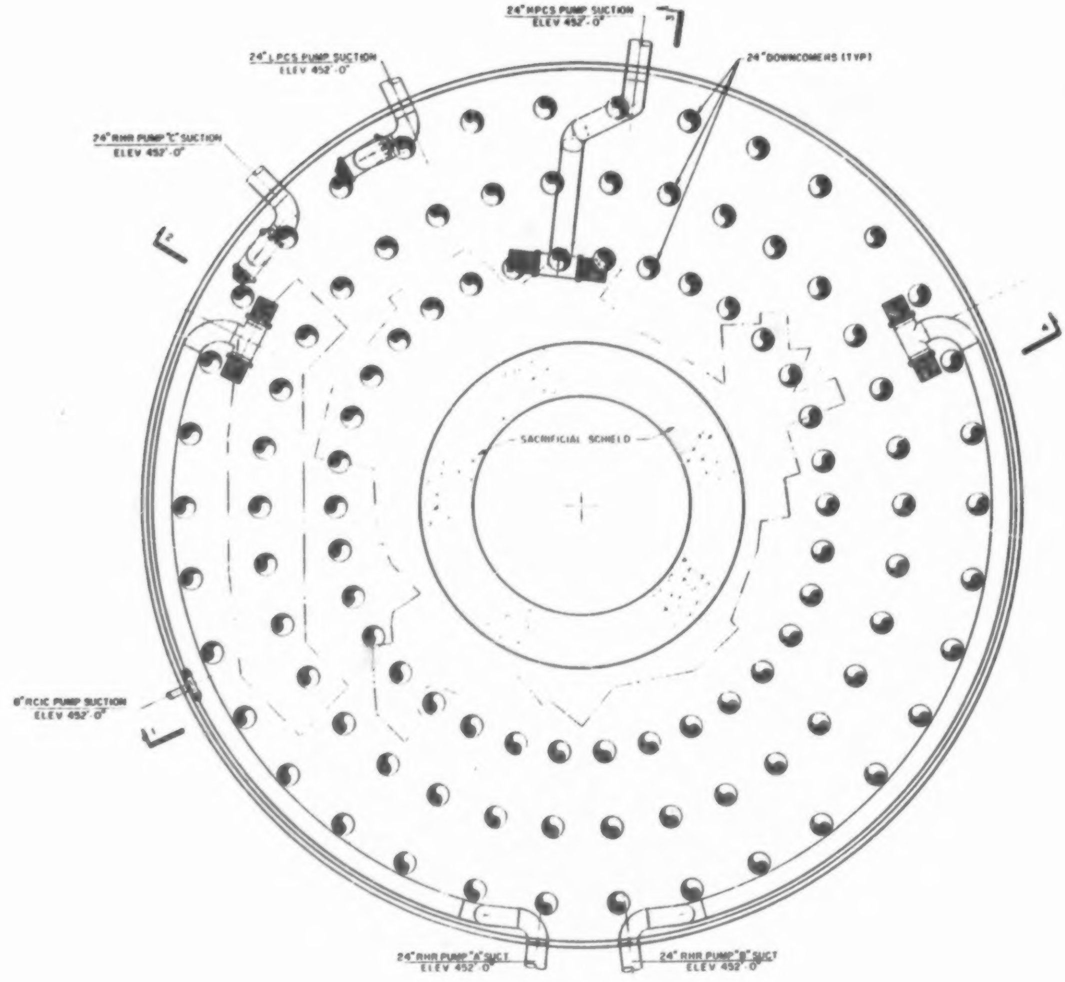

24" HPCS PUMP SUCTION
ELEV 452'-0"
24" LPCS PUMP SUCTION
ELEV 452'-0"
24" DOWNCOMERS (TYP)
24" RHR PUMP "C" SUCTION
ELEV 452'-0"
2
3
4
SACRIFICIAL SHIELD
8" RCIC PUMP SUCTION
ELEV 452'-0"
1
24" RHR PUMP "A" SUCT
ELEV 452'-0"
24" RHR PUMP "B" SUCT
ELEV 452'-0"

Figure M-5. Suction for ECCS pumps in wetwell,
WPPSS Unit 2

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In support of Unresolved Safety Issue A-43, "Containment Emergency Sump Performance," 11 nuclear power plants representative of different U.S. reactor manufacturers and architect-engineers were surveyed to identify and document the types and amounts of insulation used, location within containment, components insulated, material characteristics, and methods of installation and attachment. A preliminary assessment was made of the potential effects of insulation debris generated as the result of a loss-of-coolant accident (pipe break).

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